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COTTON-GROWING PROSPECTS IN FIJI

BY

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THE high price of cotton that has prevailed during the last few years, as a result of the serious shortage in production since the war period, has naturally stimulated interest in this staple in many remote parts of the world. The South Pacific has not escaped this influence, and the writer, in his dual capacity as representative of the Empire Cotton Growing Corporation in Australia and officer in control of the cotton experimental work now being undertaken by the Queensland Government, has had to answer many enquiries from various places in this portion of the world. Some of these colonies and dependencies are possibly fairly well-known, by name at any rate, to the general public; others have probably not even arrived at that meagre distinction. Of the larger and more important of these Colonies, such as Fiji and New Guinea, something is usually known in a general way, but real knowledge of the physiographical and social features of these groups is often most distressingly absent. Advice on cotton growing has been applied for from the Samoan and Fijian groups, and from Norfolk Island, New Guinea, and Papua. Certain Australian capitalists who are interesting themselves in cotton growing in the Portuguese colony of Timor, have also asked for help in this direction. To tell the truth, it is very difficult to give satisfactory advice in cases of this sort. Although fairly detailed descriptions are usually supplied of the soils, general features, and climatic and rainfall conditions, it is not possible to make definite recommendations unless the area can be visited and these details studied on the spot. In such instances, therefore, all that can be done is to suggest the carrying on of certain

lines of experiment in the hope that these will enable the grower to solve some of the local problems he is bound to meet. The best time for planting, the correct distance for spacing, and other cultural details, can be best studied by the planter himself, and all that can be done is to suggest the broad lines on which such experiments should be conducted. It is hoped that a certain amount of assistance has been afforded in this direction, and it is believed that the small quantities of seed of certain pure varieties that it has been possible to supply for experimental trials have been really appreciated.

In this article, however, it is proposed to confine attention to perhaps the most important of these Pacific colonies, and to give a brief account of the cotton growing prospects of Fiji as they appeared to the writer, as the result of observations made during a tour in that interesting group of islands in July and August, 1924.

The Fiji group, lying as it does on the direct course of mail steamers plying between Sydney and Vancouver, is perhaps better known than others of the numerous archipelagos that dot the broad surface of the South Pacific Ocean. The visitor by the mail steamer, however, usually only stops at Suva, the capital, for a few hours, and, although he may be impressed by the rainfall and the luxuriant vegetation, can carry away with him only a superficial idea of the potentialities of the colony. He cannot visualize the extent of cultural land available nor gain a real insight into the climatic conditions, since Suva is situated in the wettest part of the group, and the climate in consequence is often oppressively warm and humid. It is possible that if the capital had been located in the leeward and drier portion of the main island (Viti Levu), he would carry away a better impression of the possibilities of this group.

The considerable size of this colony is not generally appreciated. The group consists of about 250 islands of varying sizes, the largest island (Viti Levu) being over 4,000 square miles in extent, or rather larger than Jamaica, whilst the second largest island (Vanua Levu) is 2,128 square miles in extent. There are several other islands, such as Kadavu and Tailevu, which are also of considerable size. Generally speaking, the surface of these islands is mountainous, the main range on Viti Levu exceeding 4,000 feet in altitude in places. Numerous valleys possessing excellent alluvial flats occur, and in many parts the slopes are fairly gradual, and are covered with a fair depth of soil, which, if, for instance, they had happened to be situated in the

foot-hills of the Himalayas or in Java, would undoubtedly be terraced and closely cultivated almost up to the summits. This is particularly the case on some of the larger rivers, such as the Rewa, which is navigable for some sixty miles by small launches; the Sigatoka and Baa Rivers on Viti Levu, and the Dreketi on Vanua Levu. These river systems contain considerable areas of fertile soils in their basins, and have extensive delta lands. The same is also the case with the numerous smaller rivers, but to a lesser extent. Climatically the two larger islands are divided into two distinct zones, varying in the degree of rainfall. The prevailing winds are the south-east trades, and these meeting the main range of mountains which forms the backbone of both the main islands, cause heavy precipitation in the southern and eastern parts. The rainfall at Suva, for instance, is about 150 inches, and the climate is very humid as a result. This wet zone is characterized by dense rain forest, which forms an impenetrable jungle in all the remoter parts. On the leeward side of the island the change is striking. The high mountains have robbed the air of much of its moisture, and the climate is therefore drier and much more bracing. The rainfall is much lighter, varying from 50 to 80 inches, with a definite wet season lasting from December to March. The natural vegetation is correlated with the difference in rainfall to a remarkable degree, and instead of heavy rain forests one finds open rolling downs covered with a species of reed-like grass, the forest being confined to small isolated patches along the river valleys. It is in the dry zone, which comprises about half the area in each of the two main islands, that cotton growing is likely to do best, since, although promising results have been obtained on some of the smaller islands possessing a fairly dry climate, difficulties of transport may arise which will perhaps tend to make cotton production not so profitable as it otherwise would be.

Cotton growing is not a new industry in this colony. The high price of cotton during the American Civil War period caused quite a considerable amount of attention to be directed to this crop in Fiji. The first record of any cotton being exported from the colony is in the year 1860, when 1,000 lbs. were shipped to Manchester. High prices resulted in a boom, and cultivation rapidly increased for about ten or twelve years, when the sudden drop caused by the re-establishment of normal conditions in the Southern States of America caused a slump. High freights, due to inadequate shipping facilities and the great distance of this colony from the principal markets and mills, caused cotton cultivation to become unprofitable, so that production

almost ceased. The accompanying table indicates that during this boom period the crop produced was of considerable value:

Year.	*Tons.*	*Value* (£).
1862	12	360
1863	30	900
1864	100	3,000
1865	120	9,200
1866	294	19,800
1867	379	34,001
1868	274	30,975
1869	525	45,000
1870	—	92,700
1872-73	—	76,450

In this period cotton was mainly grown on the plantation system by European planters, employing either local Fijians—who, it must be remembered, were much more numerous than they are at present—or labourers indentured from other islands in the South Pacific. During the height of the boom, cotton was apparently grown all over the colony, both in the wet zone and in the drier portions. Thus, for a year or two quite a number of small planters are reported to have cultivated cotton on the Rewa River, a district which is certainly one of the wettest in Fiji. Inquiries from old residents, however, lead one to the conclusion that these wet zone plantations were not altogether a success, and that, owing to low yields per acre and the poor quality of the lint produced, they were the first to be abandoned. In the drier areas to the leeward, cotton growing was able to last out much longer, and it seems probable that it is in these areas that the crop is likely to be most successful at the present time. Most of the bigger islands in those days grew cotton. Taveuni, for instance, which is now given over solely to copra production, was noted for its cotton, and the same was the case with Kadavu. The planters grew the Sea Island variety, and apparently the quality, from some districts at any rate, was excellent, since a sample from this colony was awarded the first prize at the Franco-British Exhibition in London in 1908. During the same period cotton was also grown by the Fijian natives working, as is their custom at the present day, on the community system. Their taxes were paid in cotton to a large extent. The variety grown was a perennial kidney cotton (*G. brasiliense*) giving a rather coarse harsh cotton of staple averaging about 1⅛ inches. The Fijians always selected well-drained alluvial flats for their cotton crops, and many of those terraces will still be pointed out by old men in the villages. In the neighbourhood of these villages one often comes across trees of this variety, relics of the old days.

The high prices that have been ruling during the post war period have again stimulated interest in this crop. Selected Sea Island cotton seed was imported from the West Indies three years ago, and seed distributed by the Agricultural Department. European planters are nowadays few and far between, and, with a few exceptions, cotton at the present time is being cultivated by the small-holding Indian peasant farmer. The progress shown with this crop during the last two seasons, in spite of the various drawbacks that are inevitable when a new industry of this sort is being started, is promising. The total crop in 1922-23 was 33,939 lbs. of lint, and of this 33,070 lbs. were shipped overseas. In 1923-24 the corresponding figures were 62,875 and 61,197 lbs. In the former year there were 270 growers, and in 1923-24 there were 526, many of whom, however, planted only small trial plots. The 1922-23 crop realized approximately £3,500 in the Liverpool market.

At present, cotton growing is practically confined to a portion of the dry zone in Viti Levu. This is the area that has been chiefly developed by the big sugar companies for the cultivation of sugar cane, and there is also a large area in the corresponding zone in the neighbourhood of Labasa on Vanua Levu. The cane is grown on the fringe of flat land that extends around the greater part of the coast, and for some few miles inland along the deltas of the main rivers. The inland valleys are, as a rule, too isolated, and contain too small an area of suitable caneland, to make it worth while to extend the railroad. The result is that no cane is grown away from the extensive flats, since without rapid and easy transport to the cane mills this crop cannot profitably be grown. It is in these narrow valleys, between the main range of mountains and the cane belt on the coast, that cotton is being mostly grown at present by Indian cultivators farming small areas. These men were formerly indentured coolies working in the cane fields for the big companies. When the indenture system was abolished in 1916, however, a certain number of them, and more particularly those of the agricultural castes, took the opportunity of settling on land, usually leasing it from a European landowner or from one of the Fiji chiefs. Indians of this type usually have a passionate desire to farm, and, if possible, possess, a piece of land of their own on which they can erect a house, and live in accordance with their traditional customs. At present, in Fiji, there seems to be a certain number of landless men of this type who are anxious to secure a small-holding to farm. If they can obtain land within reasonable distance of the railway, and it is suitable in character, they will probably grow cane by preference, as they find

it usually a very profitable crop. Many of them, however, have had to occupy valleys further away, and these are the people who are now starting cotton growing. They naturally have to grow a cash crop, and are finding cotton the most suitable to local conditions. In addition to cotton, they usually cultivate their own food grains, and these are generally the crops to which they were accustomed in India. The lower and more marshy portions of their holdings are roughly terraced and planted with rice. The better drained portions are sown with rahar (*Cajanus indicus*), the familiar pigeon pea or dhall of India, in rotation with cotton; whilst other crops one sees are occasional patches of barley in the driest parts of the zone, ground-nuts, maize, and urid or *Phaseolus mungo*. This development has shown a marked increase during the last three or four years, but a difficulty has now arisen with regard to the transport of cotton and other produce to market. There is only one railway on the main island, and that is the narrow-gauge cane line which runs from the Sigatoka Valley right round the west and north coast through Lautoka, the main settlement and the site of a large sugar mill, to Baa and Tavua, a total distance of perhaps 120 miles. This railway was built by, and is the property of, the Colonial Sugar Refining Company, and under the original agreement with the Government they agreed to carry all passengers free of charge and convey such goods as were the property of the Government. They are not compelled to convey private goods, and it is possible that they may enforce this part of their contract and refuse to carry cotton and other private produce. It seems probable that the sugar companies are viewing with some alarm this increasing tendency on the part of the Indian to settle down on his own holding, and fear a labour shortage. In view of the great work they have undoubtedly done in developing this colony, their attitude cannot perhaps be wondered at, more especially as they have been cut off from their main source of labour by the abolition of the indenture system of recruiting. On the other hand, it must be remembered that the Indian is now free, within limitations, to settle where he likes in the colony, and if he is cut off from his markets in one place, he will naturally tend to migrate elsewhere. It is possible that it would be better in the long run for the sugar industry, if the hinterland behind the cane-growing areas were filled up with families of Indians occupying small holdings and forming a potential labour reserve, rather than that this area should be empty. Whatever the result of the dispute may be, the fact remains that the Indian settler is complaining of the difficulty in getting his cotton to the Government ginnery at Lautoka. Up

to the present he has been bringing his crop on head loads, or on a primitive sort of sledge called a "gazeta," drawn by bullocks to the nearest point of the railway, and has relied on getting it in by rail from there to the ginnery. It was a continual source of surprise to the writer to observe the total absence of country carts and bullock waggons in the Indian settlements. One cannot help thinking that the transport difficulty could be, to some extent, solved, if bullock carts were introduced and their use encouraged. It is true that the country is rough in places, but it is certainly no rougher than in some of the cotton-growing tracts of Central India, where cotton is universally conveyed to the ginnery by this means from distances of twenty miles or more. Furthermore, during the picking season the land is dry and rain falls at comparatively infrequent intervals, so excessive mud or flooded streams would not afford insuperable difficulties.

There is a large amount of suitable land available, both in the form of privately owned estates and as Crown Lands. On the coast itself considerable areas of good land are not yet occupied for cane on both the main islands, and several of the inland valleys possess large acreages. In addition, one or two of the other islands could grow a lot of cotton, although the question of transport by sea to the port of export would have to be solved, and would naturally add somewhat to the cost of production. The chief obstacle to any rapid increase in output is not scarcity of land, but lack of population. The census of 1921 showed a total population of 157,266 persons in the colony. There are roughly 4,000 Europeans, 85,000 Fijians, and 61,000 Indians. The latter are increasing rapidly in number through natural causes, since immigration from India has practically ceased for the time being. So far as one could gather, the Indians are very well contented with their lot, and appreciate the fertility of the soil and the reliable rainfall, which they compare with the conditions under which many of them formerly strove to eke out an existence on the land in their native country. Some of the older men wish to revisit India, mainly for sentimental reasons, but it is doubtful whether they would care to sever their connection permanently with the colony. Some of them are very prosperous and are in a big way of business. One elderly man, for instance, who had landed some thirty years before as an indentured coolie for the sugar plantations with a rupee in his pocket, informed the writer that he had 1,000 acres under cane on a share-farming basis. He wished to pay another visit to India, chiefly, so far as one could gather, in order that he might see once again Benares, the holy city of Kashi, and bathe in the sacred

waters of the Ganges. The general opinion, however, can perhaps be best illustrated by the remark of an old Mahomedan agriculturist who originally came from the district of Farrukabad. He argued that a country is obviously very good that can produce stalwart men and sturdy bullocks. To illustrate his point, he produced a fine pair of grade shorthorn bullocks and two of his sons, who were great strapping lads, half as big again as their sire!

There are two points about these Indian settlements in particular that must strike anyone who is acquainted with rural conditions in India as very strange. The first is the complete absence of caste. This is perhaps accounted for by the fact that the coolies were originally recruited for the cane plantations from all castes and races in India, but the lower castes, being generally in more indigent circumstances, naturally predominated. Under the social conditions under which these men lived after arrival in this colony, the caste system was found unworkable, and rapidly came to be forgotten. At the present time one occasionally comes across a kind of itinerant priest, but these men seem to be more of the nature of "fakirs" or holy men, and although they are regarded with respect, do not appear to exercise much sway over temporal affairs.

The second point is the absence of villages. There is no village community such as invariably occurs in rural India, but the settlers live apart in houses built on their individual holdings. The reason for this is presumably the peaceful and orderly conditions under which those people have been able to spend their lives since they first arrived in the colony. The ryots in India were originally compelled to congregate in villages as a means of defence against marauding armies. There are no dacoits in Fiji, and no traditions of "Pindari" raids. The Indian cultivator, therefore, lives in security on his own holding, and does not have to waste time in getting his cattle and implements to his fields each morning.

The native Fijian is physically a magnificent specimen of humanity. In many respects they are most delightful people, owning a cheerful temperament and a rich sense of humour. Possessing a strangely philosophical outlook on life, they are popularly supposed to be inclined to indolence, but one is inclined to think that they may have been sometimes misunderstood in this respect. A good deal seems to depend on how they are handled. They are naturally of an independent disposition, but if managed by a person who understands their ways and knows their language, it seems evident that they are capable of doing excellent and intelligent work. The Indian is the cane cutter *par excellence*, but the Fijians are also beginning

to take to this work. The latter, however, are at their best in the coco-nut plantations and in copra production generally. They are also interested in the cultivation of bananas for export. As sailors they are unsurpassed, and much of the labour on the wharves is done by them. The social life of the Fijian is a complete contrast to that of the Indian, and the two races keep quite apart. The Fijians, unlike the East Indians, live in definite communities. Each of the villages possesses a definite area of land, part of which is set aside for cultivation. Each member of the community has to cultivate a certain area, and the produce of these gardens is pooled by the village as a whole. Agriculture in these gardens is confined solely to the raising of food crops, which consist of various roots and vegetables, such as the taro or cassava, dalu or yams, and certain fruits, such as the papaw or mummy apple (as it is called in Fiji), the coco-nut, and banana. Generally speaking, the Fijian cannot be said to have learnt the use of improved agricultural implements. Until the white man arrived a comparatively few years ago, iron was unknown, and, in fact, the Fijian had no word for this metal in his vocabulary. Being slow to accommodate himself to new ideas and intensely conservative by nature, the village Fijian still, as a rule, contents himself with the methods of his forefathers, and the chief implement he employs in his garden is the "doko," a sharp stick, although the hoe and mattock are now coming into general favour. Unlike the Indian, however, he has rarely learnt to plough. In fact, he is a cheery optimist, and so long as bountiful nature can supplement his rough and ready methods by furnishing him sufficient food to supply his immediate wants, he much prefers to enjoy life in his own quiet way without unduly exerting himself. He is not avaricious, and until recently his simple wants have been easily met from his gardens, the neighbouring jungle, or the surrounding seas. There are certain signs, however, that this *dolce-far-niente* phase is beginning to pass, and the native Fijian to adopt a more vigorous attitude towards life. As a whole, the modern generation is now far better educated, and owing to the fact that it is beginning to come up against the struggle for existence, it is showing more signs of adaptation to present-day conditions. The necessities and incidentally the comforts of modern civilization are also beginning to be appreciated. In two small and isolated Fijian villages the writer visited, the community had set to work and constructed a pure water supply. In one village, many miles away from other habitation, a spring had been tapped in the hills and a cement cistern constructed, from which a pipe-line three miles long led the pure spring water to a stand erected in the middle

of the village green. This had been done entirely on their own initiative. Here and there also one meets Fijians who have begun to cultivate cash crops, and have managed to get away from the old idea that all that was necessary was to cultivate sufficient food for their own immediate wants. Some of those men are using ploughs and improved implements with excellent result, and no doubt their good example and pressure of circumstances will in time result in others doing likewise. There is no doubt that the up-to-date methods employed by the sugar companies in their plantations, and the practical training given to the Indians, has raised the standard of cultivation amongst that race, and it is hoped that it will result in equal benefit to the Fijians, although progress amongst the latter will naturally be slower. The success of the cotton crop with the Indian growers has certainly stimulated an interest in this crop amongst the Fijians, and it is possible that if some system of demonstrating proper agricultural methods could be adopted, they should in time be capable of growing an appreciable area. In many of the villages the "buli" (headman), or the older men, will show you the areas that were formerly cultivated to cotton in the older days, and it must be admitted that the sites were invariably well selected and the soils suitable.

The variety of cotton now being grown is Sea Island, and selected seed was imported from Barbados about three years ago through the Department of Agriculture in the West Indies, and distributed to the cultivators. A few European planters are trying the seed, but the majority of the applicants were Indians, who wished to grow the crop on their small-holdings. A few of the more progressive Fijians also applied for seed, and in one or two cases achieved considerable results. In other cases, however, mistakes were made in certain fundamental details. One Fijian grower, for instance, had received his seed far too late, and had to plant in April, which is probably three or four months later than is desirable. Proposals are now on foot to train itinerant demonstrators who will be able to journey from district to district, advising individual growers on the more important details with regard to the crop. The Indians, who are growing the major part of the crop, are, on the whole, doing well, but naturally a great deal of instruction and practical demonstration is required before the best results can be expected. It must be remembered that the Indians were, in the first place, recruited from all parts of India, and comprise many different castes and races. Many of them, particularly the Madrassis and Ooriyas, have probably never seen cotton growing before, and they naturally often make mistakes in their cultivation and plant the wrong sort of land. The best cotton growers appear

to be those who originally came from the Ganges plain and the neighbouring parts of Behar, the United Provinces, or the Eastern Punjab. A number of these men have "squatted" on the land and, being agriculturists by tradition and used to "dry" cultivation, are getting good results, as they seem naturally to pick out the best soils and situations for their cotton crops. Some of these cultivators have achieved really extraordinary results, considering the handicap under which they work and their lack of experience with Sea Island cotton. The latest reports received show that in the neighbourhood of Vitua Levu in the Nadi Valley, where the cultivators are growing cotton on secondary terraces of alluvial loam, or on light, well-drained black soil slopes overlying friable basalt, the average was about 1,600 lbs. of seed cotton per acre, whilst one or two fields have gone up to 2,000 lbs. per acre. This means a cash return of over £30 per acre, and since the cultivation and picking is done by the man and his family, it represents practically all profit. These returns are, however, exceptional, and are only indicative of what can be done by the adoption of intelligent methods. Many of the growers were entirely ignorant of the crop, and got very poor results, and this has lowered the average on the whole. Nevertheless, the following statement is distinctly encouraging, as it shows progress:

	1923 24.	1922 23.
Total crop, lint cotton	62,875 lbs.	33,930 lbs.
Crop shipped, lint cotton	61,190 lbs.	33,070 lbs.
Average yield seed cotton per acre	424 lbs.	232 lbs.
Average size of cotton plot	1·11 acres.	1·9 acres.
Number of growers	526	270

The most satisfactory feature of these statistics is that the yield per acre has increased considerably, showing that the growers are beginning to understand the crop better. Judicious demonstrations by trained men would undoubtedly hasten the process, and a leaflet giving essential points on the cultivation of the crop has been distributed by the local Agricultural Department, and published in English, Fijian, and Hindu. The chief points where the growers are making mistakes are in the choice of land, in the time of planting, and in the spacing. Well-drained slopes containing a fair depth of good soil are essential, and many Indians new to the crop are planting on shallow soils overlying solid basalt or soapstone. In other places the site chosen was too water-logged, and would probably suit rice better. With regard to the time of planting, experience is beginning to indicate

that so far as the Sea Island variety is concerned, the best time to plant is in November and December. If planted after New Year the plants seem to suffer more severely from the tip worm (*Earias spp.*), and do not generally yield so well as the earlier sown crops. Spacing is another matter that is not yet properly understood. Some of the Indians who were accustomed to grow East Indian (herbaceum) types left their plants far too close together, and would undoubtedly have achieved more satisfactory results if they had chopped their plants out to about 2 feet. Similarly, there was a tendency to plant the rows too close together. These mistakes are, however, likely to become less frequent as the result of experience.

The chief complaint by Europeans and Indians against the Sea Island variety is the cost of picking, owing to the small size of the bolls and also to the necessity for frequent picking, so as to ensure that the cotton is of high grade and not weather-stained.

The Fiji Agricultural Department has from the start realized the necessity for strict grading, and has accordingly fixed four grades for seed cotton delivered at the ginnery. In order to emphasize the necessity for clean picking, there is a considerable differentiation in the prices advanced by Government, which for the season 1923-24 crop were as follows:

Grade.	*Per Lb.*	
A	4d.	The balance after completion of sales is distributed as a bonus to growers.
B	3d.	
C	2d.	
D	1½d.	

This system is proving satisfactory, and, owing to this careful grading, satisfactory reports and prices were obtained for the 1922-23 crop. The price realized for 101 bales of 380 lbs. each was nearly 25d. per lb., and the reports indicated that the Fijian Sea Island cotton was in strong demand, special mention being made of its strength.

It is probable that this strength of staple in Fiji Sea Island cotton is due to the comparative absence of insect and fungoid attack that was so noticeable at the time of the writer's visit. Odd cases of pink boll worm were noticed, and a few specimens of shield bug (*Tectacoris*) were seen on the coast, but not a mile or two inland. A cotton stainer (*Dysdercus*) is present, and the latest reports obtained on the 1924 crop indicate that it was slightly on the increase, but only made its appearance in any quantity when two-thirds of the crop had been picked. Very little boll rot was observed. This relative absence of insect attack is possibly due to the fact that the crop is a relatively new one in recent times, but is also probably accounted

for by the fact that the departmental authorities have insisted on a close season, and are endeavouring to enforce the provision that all cotton must be uprooted and burnt by the middle of October each year.

The type of Sea Island now being grown is producing a boll of fair size (for this variety), which opens well, and is not too difficult to pick when well grown on the right type of soil. Nevertheless, the same tally naturally cannot be made on this variety as on Upland cotton, and owing to the greater importance of lustre, colour, and grade generally, it must be picked at frequent intervals. These points have caused an enquiry to be made into the possibility of growing some variety which is easier to pick. It is recognized that any variety to displace Sea Island must be of high quality, since it seems probable that only long staple cotton can stand the high shipping freights that the long sea-carriage to the markets entails. The Department have been conducting experiments in a small way with Pima, Meade, and Durango. Curiously enough, the Pima variety, although it is growing under conditions that would not seem suitable to Egyptian varieties, is doing singularly well. One plot is situated on a well-drained red gravelly soil close to Lautoka, and within a mile of the seashore, and was planted in November. Another test plot was planted in the middle Sigatoka Valley in a district that probably has a rainfall of 80 or 90 inches, and, although it was not planted until late January, was looking well and exceedingly healthy and free from disease at the time of the writer's visit. These two plots yielded exceptionally well in 1924, the Lautoka plot yielding over 2,000 lbs. of seed cotton to the acre. The cotton produced appeared to run about $1\frac{5}{8}$ inches in staple, was of great strength, slightly uneven, but of great body, and perhaps a little off colour. The texture was curiously enough inclined to be rough and the fibres a little coarse, but it appeared to be a very useful type of cotton, and the reports on the values of two bales despatched to Liverpool will be awaited with interest. It is somewhat curious that a cotton of Egyptian origin should give these results, as the humid climate of Fiji is totally unlike the dry atmosphere under which this class of cotton thrives in other parts of the world. One would expect it to suffer from "black-arm" and other diseases, but so far it has again, according to report received, remained remarkably healthy in the present season. Durango and Meade are also being tested, and it is yet too early to state how they are likely to thrive, but there are indications that the former in particular will be subject to "boll-rots" of different sorts, more especially if planted early.

In view, therefore, of the encouraging reports received of the sales of Fiji Sea Island up to date, and also having regard to the tendency for the long staple market to harden, due to a gradual return to pre-war prosperity, it will probably be advisable to concentrate on this type for the time being. The local authorities are fully alive to the importance of keeping the seed pure, and special areas of the best cotton-producing areas are being reserved for seed in the dry belt on Vanua Levu. Production and the supply of seed is completely controlled by the Government Agricultural Department, so that the danger of deterioration through cross-pollination with an outside variety is remote, since the tests with other types are being conducted on isolated plots under the strict control of Department officials. The danger of mixing at the gins is also remote, since here, again, the Agricultural Department controls the ginning, and the experimental varieties are not ginned until the end of the season.

Sufficient of these beautiful islands was seen by the writer to realize that there is plenty of land for cotton growing. Large tracts are at present being held by absentee landlords who would undoubtedly be glad to see them more closely settled, if a profitable commercial crop could be introduced that would not require too much outlay of capital. Many of these areas are at present used as cattle runs, and are not returning much profit, whilst they are in some cases becoming rapidly overrun with wild guava, which forms nearly impenetrable thickets, and can only really be successfully dealt with by close settlement.

The best cotton area is undoubtedly on the lee side of Viti Levu in the area behind the cane belts, but it is probable that considerable areas of suitable cotton land also occur, more particularly perhaps in the valleys of the Dreketi and Sarawaga rivers. Here, however, development is bound to be somewhat slow to start with, as few communications exist, and facilities for handling, marketing, and transporting the crop will have to be provided.

The deciding factor is, of course, population, and there is no doubt that Fiji is under-populated, having regard to its fertility and splendid climate. There are several established and flourishing industries already in the colony, and these will naturally demand the greater part of the labour, but there is nevertheless room for the development of a sound cotton-growing industry, and this should develop with the growth of the population into a most valuable asset, as it provides a suitable crop for the new settler who is not blessed with a great amount of capital.

OOMRAS COTTON: THE PROBLEM OF THE SHORT STAPLE

BY

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Economic Botanist for Cotton to the Government, Central Provinces and Berar

PART II

THE influences at work in bringing about the substitution of a superior by an inferior cotton in the oomras tracts are such as might play a part at any time, anywhere, amongst a primitive peasantry. For this reason, if for no other, they may be of interest to those who have any concern with cotton improvement. We have, too, in Hyderabad and the other oomras regions, Berar especially, excellent material for a comparative, economic, and statistical study. The soil of Berar is in no way inferior to that of Hyderabad, and the provinces are contiguous. For these and other reasons, we will more especially make a comparison between these two tracts.

The first question that naturally presents itself is the one—Was not this coarse cotton taken up in preference to the former types because of its increased yield per acre in comparison with them?

The following table of the cotton crop of Berar is compiled from the official "Agricultural Statistics of India":

TABLE A.—BERAR.

ACREAGE AND YIELD OF COTTON (GINNED) EXPRESSED AS AVERAGES OF FIVE-YEAR PERIODS.

Period Ending—*	*Acreage.*	*Bales* (400 *lbs.*).	*Normal Outturn Per Acre in Lbs.*†
1901–02‡	2,364,218	501,040	144
1906 07	3,033,327	595,814	100
1911–12	3,132,104	526,000	86
1916 17	3,120,655	653,000	86
1921–22	3,089,591	592,600	86

* The cotton season from planting to end of picking (June to March) occupies portions of two years.

† This column requires a little explanation. In the words of the Director of Statistics: "The normal outturn per acre is briefly defined to be the average yield on average soil in a year of average character. This normal or average outturn does not necessarily correspond with the average figure for a series of years, which is an arithmetical abstraction, and may possibly never occur. The Agricultural Department in each province maintains a statement of the normal yield per acre of crops."

‡ This period embraced years of famine.

It should be remarked that the early figures of Table A are probably not so accurate as those for later years. This applies, perhaps, especially to normal outturn per acre, but the point of real importance is that this figure has shown no rise. In the two seasons since 1921-22 it has further declined to 83 lbs.

The substitution of an unmixed crop of the modern short staple for what was previously grown has occurred within the last twenty years covered in Table A. Contrary to general opinion, the official statistics do not show an increasing yield per acre due to its introduction. In fact, if the conception of "average soil" and "a year of average character" does not vary, or if they could be defined by mathematical units, the column "normal outturn per acre" would indicate with mathematical precision that the crop, from the point of view of the plant grown, or the cultivation given to the soil, or both, has gone from bad to worse. The arithmetical average yields for the series of years also do not indicate a progressive increase. We can see what has happened. There has been an increase in the number of acres planted with cotton, and consequently an increased amount of produce—that is, the method of increasing the mass of produce by increasing the area sown is the simple one that has been followed. This method of increasing production is not a new one in the agricultural history of the older nations of the world, and India must be ranked as one of them.

Everything indicates that this increased amount of cotton has been grown without sufficient attention to proper agricultural practice or rotation. The land has been growing more cotton than it should, resulting in soil impoverishment. An increase in the amount of fallow has occurred according to statistics, but that there has been no increase in the yield per acre shows that it has not had the effect that it would have done if it had been proper fallow in an organized rotation system. It is difficult to know what value should be attached to this so-called fallow. Much of the fallow land is simply enforced uncropped area, due to vagaries of India's variable monsoon, or to the fact that it is absolutely too exhausted and useless without a rest for further cropping. For this reason, it is an open question whether the area sown to all crops be not a truer index of the state of affairs than the total "cultivated" area. The official figures show no progressive increase of the total area sown to all crops. The area then under cotton has increased by cutting down the area previously planted with some other crops. Statistics show plainly what these crops were. The total area under food grains (cereals and pulses) has shown a steady decrease, wheat having considerably diminished,

and also the leguminous crop known as "gram" (*Cicer arietinum*). Linseed and other oil seed crops have, too, shown a steady decline. The large millet, juar (*Andropogon sorghum*), the main cereal crop that has been grown, and which is the staple food of the people, has shown a serious decrease.

TABLE B.—BERAR.

NUMBER OF ACRES UNDER PRINCIPAL CROPS OTHER THAN COTTON, EXPRESSED AS AVERAGES FOR FIVE-YEAR PERIODS.

Period Ending—	*Net Area Sown to All Crops (Cotton Included).*	*Total Cereals and Pulses.*	*Wheat.*	*Gram.*	*Juar.*	*Linseed.*	*Total Oil Seeds.*
1901–02	6,529,391	3,715,463	277,227	139,598	2,804,081	144,388	354,934
1906–07	7,361,381	3,927,239	392,292	165,431	2,805,768	122,509	309,438
1911–12	7,231,341	3,775,877	318,273	150,774	2,560,632	74,166	238,253
1916–17	6,979,270	3,554,597	356,715	121,773	2,304,602	61,515	212,257
1921–22	6,731,556	3,437,945	209,055	74,028	2,414,167	26,678	130,684

The crops the acreage of which has so dwindled away were no doubt less profitable ones than cotton. The serious point is, however, that they were rotation crops following cotton, and enabling the land to recuperate after the latter crop. They, too, were a rotation of a particularly advantageous kind. The large millet (*Andropogon sorghum*) is planted at the same time as cotton. The rest are all planted much later in the year, in the autumn. Thus, these autumn sown crops, beside giving the land a rotation, give a rest or short fallow period, intervening from the time the cotton was over in the early spring to their sowing time. For this reason, and for the fact that they are not so exacting from the soil (linseed excepted), they were a better rotation than millet.

The increasing appearance of wilt disease in the cotton fields of Berar would seem to be connected with the absence of proper rotation. Wilt disease is in all probability a manifestation of plant malnutrition.

The decrease in the area sown to cereals has unfortunately another serious aspect, besides the impoverishment of the soil by diminishing the rotation.

The stalks of the cereal crops in India are practically the only food fed to neat stock. The neat stock between the season 1902-03 and that of 1921-22 in Berar increased by over half a million head. What this means it is difficult for one, if unacquainted with India, to imagine. Consuming all, but even then a totally insufficient, food

supply, their droppings rarely or never serving as manure, but as fuel, an excessive number of cattle is a heavy incubus on the countryside. The cows are so poor that their milk is of the smallest quantity and most execrable quality. Milk in the towns of Berar, owing to the scarcity of fodder, is dearer than in London or New York. Infant mortality, as might be expected, is something appalling.

TABLE C.—OOMRAS COTTON.

YIELD PER ACRE OF GINNED COTTON IN LBS. AND COMPARATIVE VALUES.

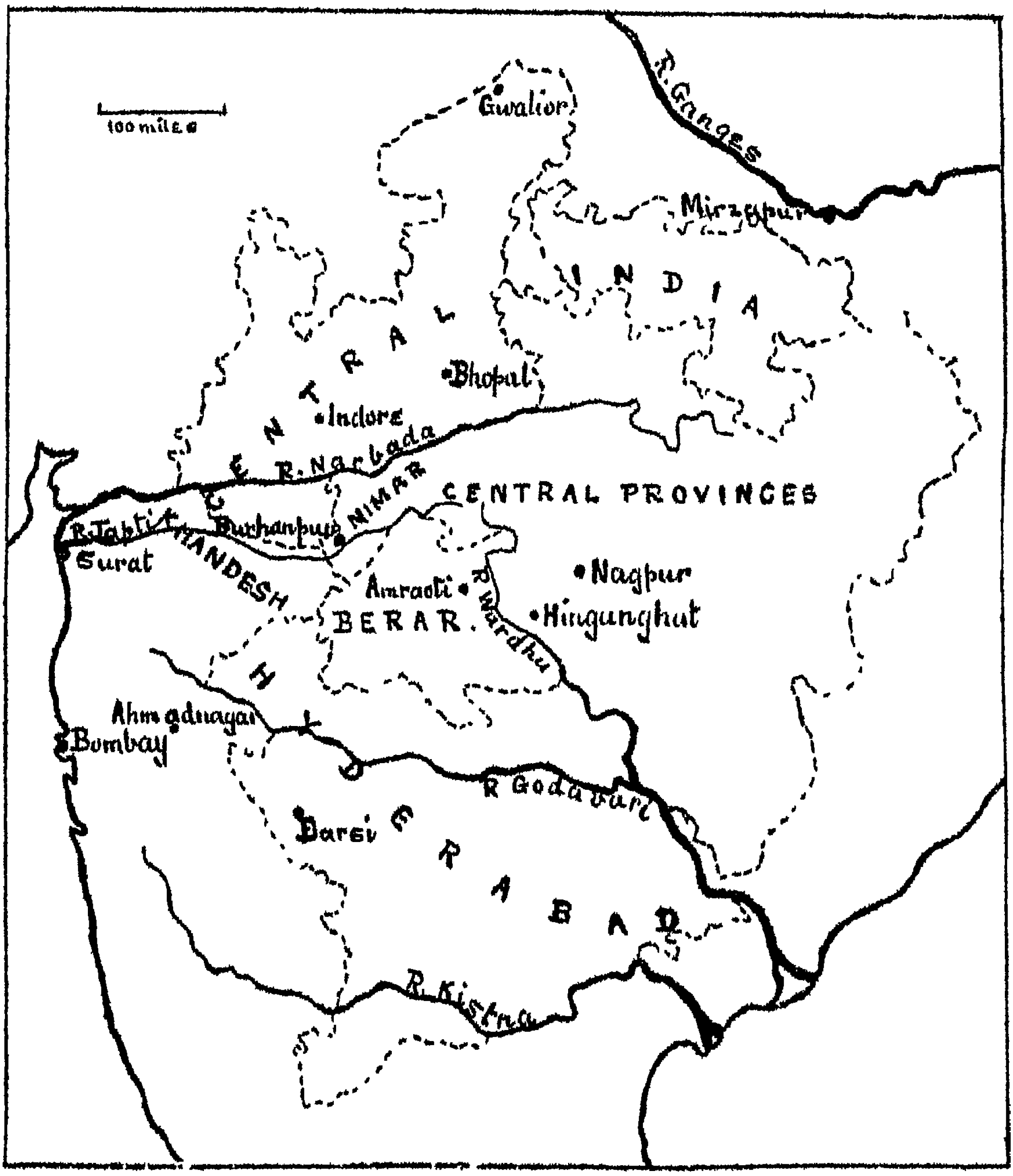
	1919–20.	1920–21.	1921–22.	1922–23.	1923–24.	*Average of Last Five Years.*	*Comparative Price per Bale (400 lbs.).*	*Comparative Value of Lint Per Acre.*
Khandesh ..	121	51	104	94	81	90·2	Rs. 200	Rs. 45
Central India ..	55	49	76	72	64	63·2	Rs. 210	Rs. 33
Berar	120	37	104	83	84	85·6	Rs. 220	Rs. 47
Central Provinces	96	67	97	92	80	86·4	Rs. 240	Rs. 52
Baisi and Nagar	81	61	100	115	117	94·8	Rs. 240	Rs. 57
Gaorani	118	55	149	125	143	117·6	Rs. 260	Rs. 76

Note.—The rupee may be taken as Rs. 15 = £1 sterling.

The figures of yield per acre in Table C are the same as those given by John A. Todd in the *Empire Cotton Growing Review*, Vol. I., No. 3, p. 223. It should be noticed that these figures do not correspond with the figures given in the official Agricultural Statistics of India. As explained in connection with Table B, the figures there are "normal outturns," which are supposed to represent a nearer approach to a correct estimate than can be obtained by simply dividing the total weight of cotton in the returns by the acreage. The "yield per acre" obtained in this latter way is what is given in Table C. The chief objection to it is that the amount of cotton given in the official returns for each province does not include domestic consumption; it only represents the sum of the mill consumption and the export for the particular province, and therefore it is not strictly the total yield. This "yield per acre" has been given in Table C, for we are not in possession of the "normal outturns" per acre for all of the oomras areas. This table is intended more especially to convey comparative rather than absolute values. It will be noticed that the yield per acre of the superior cottons is on the whole higher than that of the coarse, and that the higher prices of the last few years have especially stimulated them to increase their yield. What does this imply? It implies that superior cottons require

superior cultivation, and that the stimulus of this extra effort, where given, effects real agricultural improvement and brings its reward.

The yield of cotton per acre in India generally, and in the oomras tract especially, is miserably low, and quite capable of being doubled or even trebled.



The comparative purpose of the two last columns of Table C should especially be emphasized. They are based on the unit of Khandesh Oomras at Rs. 200 per bale, a price at which it has often stood. These comparative figures are compiled from graphs and data of prices kept by the writer. Meticulous accuracy is not claimed for them; they are, however, probably not a long way out, and may serve as a useful means of comparison. The last column, " com-

parative value of lint per acre," represents a price that the cultivator has often taken in recent years. The value of the seed is not very high, say some 20 lbs. for a rupee, and for a rough estimate take the seed at twice the weight of the cotton per acre, and, by addition of this amount, an approximation to the money realized from the produce of an acre is obtained. Only in the case of the Gaorani cotton will as much as Rs. 10 (in this case it will be some twelve) have to be added to the last column to give the value of an acre's produce. The tendency seems to be for the prices of coarser oomras to level themselves. At the present time, there are five hedge contracts officially recognized on the Bombay market for Indian cotton, of which two are concerned with the four coarser oomras first mentioned in our table. It is now being urged that a simplification and reduction of these contracts should be made so that there would be only three. The first is to include cottons of $\frac{7}{8}$-inch staple or over, and into which the Hyderabad Gaorani would go. The second is to be for cottons of not less than $\frac{1}{2}$-inch staple, and it is doubtful whether all the rest of the oomras could even come into this. The third contract is to include a miscellaneous mixture of coarse cottons of less than $\frac{5}{8}$-inch staple, now collectively, but somewhat misleadingly, known as "Bengals." The astonishing thing is that the cultivator should be content with so low a monetary return from his land. In Berar it is quite possible by good cultivation, and with prices as given above, to make from cotton a profit—a profit, be it noted, of much more per acre than is now the actual average monetary income.

These things being so, the question is—Why did the cultivator in Berar and elsewhere take to a coarse cotton that does not give him the value per acre that a finer one could, and why did he go to the extra trouble of growing a larger area in order to get more cotton rather than increase the yield per acre?

In the history of agricultural development generally there is often a period, and sometimes a long period, of time during which the conservative proclivities of cultivators make the existence possible of a sort of artificial concerted harmony or proportion between the cultivation factors producing a crop, and the monetary yield of a crop. It is a phase of inertia, like the sleep period of a humming-top, occurring when all is going well, and should not be supposed of perpetual continuity nor as making for agricultural progress. It is good for agricultural practice at times to be jogged out of its sleep and awakened to realize the factors influencing it. Amongst European nations in modern times this jogging has more often than not come with periods of war. Utopian contentment has had to give way to changed times

and new methods. During the last sixty years, India has probably been less affected by war than any country in the world.

If we had some mathematical means of expressing the environmental factors concerned in the production of the crop, such as the efficiency of the plough oxen, the quality of the soil, the amount of cultivation given to the soil, the amount of manure given to the land, the climate, and so on, we could represent things with precision, if we could estimate the working of the law of diminishing returns. On the one side we have yield per acre × value per pound; on the other the contentment of the cultivator × some unknown product of the cultivation factors. If the value per pound on one side of our equation increase, as it has steadily done in recent years in the case of cotton, then the contentment of the cultivator, on the other side, can remain the same, whilst some or all of the cultivation factors decrease. That is the true state of affairs; the cultivator has been kept content and satisfied by an increasing price per pound for his crop, and a diminution in his struggle for existence with the cultivation factors. The cultivator in the Khandesh coarse oomras tract may possibly be an exception to this statement. Coarse cotton in Khandesh is, perhaps, grown more from necessity than from choice, as already indicated. A struggle for existence, though not liked, yet is a necessary element in the improvement of organisms and industries. Good prices are, unfortunately, rarely stimulants to agricultural improvement, especially amongst a conservative peasantry.

The cultivation factors, of course, depend upon the capital of the cultivator. Money is necessary to pay for most of these factors. Yet, in spite of much talk that one hears about no money for this method, and no money for that, capital probably plays a less important part in India than in many countries. The smallness of so many of the holdings and the peculiar "joint family system" of living, whereby the family may consist of fathers, sons, and the sons' uncles, and all the female members and children of their families, pooling their earnings and living jointly on the proceeds, make the possibilities of a small capital something remarkable.

Loans of capital are obtainable in India with extraordinary facility. The word of the borrower and the bond of his friend, never mind of what his substance, are often sufficient security for the lender. A loan of seed for sowing on condition of a return of an amount of the crop, or a monetary advance upon a standing crop, are easily arranged. Unfortunately, as is bound to be the case, the interest exacted on such security is extortionately high; so high, in fact, that the value of such loans to any but the lenders is doubtful.

If the lender of money be in any way concerned with the purchase of the cotton grown by the borrower, his influence will certainly be used in determining the kind of cotton grown. The kind that he will want, as we shall show, will be one yielding on ginning a high proportion of lint to seed. The gin owner who buys cotton to gin and to sell afterwards to the merchant will want the same thing. This factor of high ginning percentage has been perhaps the greatest of all in establishing short staple cotton in Berar and other tracts.

The cultivator sells seed cotton, and by weight. The quantity he has to offer for sale is usually comparatively small; very, very rarely enough to make actual contact between him and the user possible. This introduces a system of middlemen, financiers, ginners, brokers, call them what you will. They, influenced in their turn, but as slowly and as little as possible, by the exporter's price in the case of coarse cotton, decide the price to be paid to the cultivator for the unginned cotton of a district. The cotton in the coarser oomras areas practically sells at any particular time at one uniform price throughout each area. Any slight difference in price paid by the exporters will be due not to any difference in staple length, but to the degree of whiteness of the lint and the cleanliness with which it has been picked. It, in fact, owes its value to grade or class, and not to staple specifications. Staple becomes subordinated to grade.

Under such a system as this the influence of high ginning percentage is bound to be a very serious obstacle to the improvement of staple. An unexpected fall of 8 per cent. in the ginning percentage of the cotton purchased by one ginnery in the Central Provinces in the season 1923-24 was said to be sufficient to convert a profit of previous seasons into a loss of nearly seven thousand pounds sterling in that season. This was a loss to the ginner, because he was buying at a price fixed without expecting an unusual and unforeseen ginning outturn. He had been accustomed to get cotton in the neighbourhood of his ginnery, ginning over 38 per cent. lint, and in this season it was only 30 per cent. As a rule, however, the figures are the other way. It has been stated that "the price paid to the cultivator in Berar is independent of whether the cotton yields on ginning 30 per cent., 35 per cent., or even more, for the shortest lint cotton may even approach 40 per cent. For every increase of 1 per cent. in the ratio of lint to seed in the ginning, the buyer gains by Rs. 5.12 on each thousand pounds of kapas that he buys, when he sells his lint at Rs. 500 per kandi of 800 lbs., and the seed at 20 lbs. per rupee. When he sells his lint at Rs. 475 per kandi, his gain is Rs. 5.7; at

Rs. 450 it is Rs. 5.2, and at Rs. 400 it is Rs. 4.8 for each increase of 1 per cent."*

These facts being so, we see that the key to the kind of cotton grown is largely—too largely, in fact—in the hands of the ginner or the middleman who buys the seed cotton and gets it ginned before passing the lint on to the exporter.

The great gambling element, especially when combined with some skill, which is so strong in human nature—and the nature of the Indian cotton broker is no exception—introduces an added zeal to the purchase of cotton in consequence of the variability of this ginning percentage factor.

It is only natural that every pressure should be brought to bear upon the cultivator by middlemen to make him grow higher ginning percentage cotton, rather than longer staple. Unfortunately, in all the Asiatic types of cotton, as the ginning percentage of lint to seed gets higher, the length of the staple gets lower.

These, then, are the factors at work in the coarse oomras cotton tracts against which those concerned with cotton improvement have to contend. The growing of a coarse cotton, instead of a better that the land will grow, is to backward cultivators a great temptation, because of the greater ease with which it will grow and the influence of ginning percentage. Increase of quantity of crops with a total disregard for quality is accompanied, however, by many correlations which have a disturbing effect upon agricultural economy. That the improvement of staple is a sound thing for which to strive, there seems no doubt from an economic point of view. Its improvement will carry with it an improvement in agricultural practice all round. From a broad point of view, the increase of every bale of cotton capable of spinning yarn of over 20's count is an advance. From the point of view of the requirements of Indian mills, it is very near a necessity, for unless they can soon get more of such cotton from their own country, in the near future they will have to come into the market for Egyptian or American. From the point of view of the tiller of the soil, it would be much to his material benefit, provided he obtains the fair value for his improved produce. The cultivators will, it is to be hoped, one day see this, and a longer staple cotton, even with a lower ginning percentage, will be grown. Co-operative organization and selling will be the keys to the situation.

* Kapas=seed-cotton (*i.e.*, unginned cotton). One rupee=sixteen annas An anna=one penny, and a rupee, therefore, is equivalent to one shilling and four pence. A kandi=two bales of 400 lbs. each.

A REVIEW OF THE WORK OF COTTON SEED SELECTION IN UGANDA: YEARS 1911-1925

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THE type of cotton grown in Uganda has been confined entirely to the American Upland long-stapled varieties. An Egyptian variety was tried in the years 1910 and 1911, but proved a failure.

Of the Upland varieties, Sunflower, Allens, and an acclimatized Nyasaland variety have proved successful during the period under review, particularly the Sunflower and Nyasaland.

In 1923 a number of new Upland varieties were imported and tried on the experimental stations in that year and in 1924, but none came up to the standard of quality as laid down in the selection work, and only one produced an outstanding character—viz., resistance to bud and boll shedding, which is of great importance in this country, where the cotton crop is subjected to severe climatic changes, causing profuse bud shedding and consequent reduction in yield.

This variety (Salisbury) will be subjected to further trial, and, although the staple is much below the standard in quality, an endeavour will be made to graft the above desirable character on to our improved types by artificial crossing.

The writer arrived in Uganda in October, 1911, and was instructed to proceed immediately to the Eastern Province to inaugurate and carry out the work of cotton seed selection. Serere County of the Teso District in the Eastern Province, where some experimental work with different varieties of cotton had been carried out by Mr. E. T. Bruce, Agricultural Officer, in the two preceding years, was chosen as the most suitable field for the work. To this country the writer proceeded direct, equipped with a graduated comb for combing out and measurement of staples, a medical balance for lint percentage tests, and a tin box for holding samples of cotton.

On arrival at Serere, the first work undertaken was the selection of a suitable site for the experimental station. For this purpose a tour of the county was made and two alternative sites were selected—

one at Serere and one at Kadunguru. With the advice of the late Director of Agriculture and the District Commissioner the latter site was chosen as the most suitable, because Kadunguru, situated about eight miles from the Bugondo port on Lake Kioga, was less liable to severe hailstorms than Serere, and also because the natives inhabiting that area were the most backward in the district, which is distant about fifty-four miles from the administrative headquarters at Kumi, and it was hoped that the opening of an agricultural station there with a white officer in residence would tend towards the advancement of the natives in cultural methods, and increase their ability to pay taxes.

From a health point of view, the site chosen proved to be unsatisfactory. Situated on the centre of a narrow peninsula formed by Lake Kioga, and surrounded by marshes, for the greater part of the year the place was infested by mosquitoes, upon which clearing and cultivation appeared to have little or no effect.

At that time Teso District was administered by one European officer, the District Commissioner, and a large number of Baganda agents or advisers to the native chiefs. The district had been opened to administration only some three years previously, and the chiefs were in a very raw state, the elements of slavery and barbarism being still near. As an example, when the work of clearing was started, the chiefs of the locality came in a body and protested against the payment of wages to the labourers, and it took some considerable time to convince them that the white man could not employ unpaid labour, and that paid labour was the best labour in the long run. The labourers themselves actually preferred to work unpaid, but, as this carried with it the right to come to work, and leave off, when they liked, the disadvantages were obvious, and it took many months of lecturing and exhortation to convince them that a day's work began at 7 a.m., not 10 a.m., and ended at 5 p.m., not 3 p.m.

In 1911 the cotton crop in Serere County was of the Sunflower variety, the seed having been obtained from East Africa, where it had been grown the previous year. In addition the Baganda agents at every gombolola in the county had been given seed of the same variety, which had been grown in experimental plots the previous year, from seed obtained direct from America, and sent out by the B.C.G.A. The latter was remarkably successful for a second trial of a new importation.

Cotton picking had already started when the work of selection began. An examination of the cotton in the field showed much irregularity in staple amongst the general Sunflower crop, less so

amongst the special Sunflower, although staples varying from 1 to 1⅜ inches were to be found in the latter, and the need for selection work to produce a more regular staple, at any rate, was manifest.

The next question to be decided was the line which the work of selection should take. Without any previous experience of the work, it was impossible to lay down hard and fast rules, but with the help and advice of Mr. P. H. Lamb, the Chief Agricultural Officer, it was decided to give particular attention to length, strength, and regularity of staple, and it was agreed to award the following marks on a score card:

	Marks.	*Total.*
Length of Staple:		
Less than 1¼ inches	0	—
Between 1¼ and 1⅜ inches	20	—
1⅜ inches and above	40	40
Percentage of Lint:		
Less than 27 per cent.	0	—
Between 27 and 30 per cent.	10	—
Above 30 per cent.	20	20
Strength:		
Poor strength	0	—
Medium strength	10	—
Good strength	20	20
Regularity:		
Poor regularity	0	—
Medium regularity	10	—
Good regularity	20	20
Total ..		100

Habit, productivity, etc., of the plant were not taken into consideration, because the work did not begin until late in the season, and most of the plants had been already picked of their first bolls.

It is seen that considerable stress is placed on length of staple, and an endeavour was made to establish a cotton with a very long and fine staple. This was afterwards found to be an error, and it led to a protest from the Liverpool brokers, who complained that we were producing a staple too long and weak, for which there was a very limited market.

The above was rectified in later years by the substitution of the following score card supplied by Mr. S. Simpson, Director of Agriculture, and modified to suit the conditions in this country. The latter became, and has since remained, the basis and guide of the selection work in Uganda:

A.—PLANT.

	Marks.	*Total.*
Habit:		
Erect *v.* recumbent	2	—
Compact *v.* straggling	2	—
Early *v.* late maturing	1	5
Resistance to pests:		
Insects	5	—
Fungoid diseases	10	15
Productivity:		
Under 40 bolls	0	—
Between 40 and 60 bolls	5	—
Over 60 bolls	10	10

B.—LINT.

	Marks.	*Total.*
Length of staple:		
$1\frac{3}{16}$ to $1\frac{7}{16}$ inches (5 points for each $\frac{1}{16}$ inch)	—	20
Distribution:		
Very uniform	5	—
Uniform	3	—
Fairly uniform	1	5
Regularity:		
Very regular	10	—
Regular	5	—
Fairly regular	3	10
Strength:		
Very strong	20	—
Strong	10	—
Fairly strong	5	20
Ginning percentage:		
25 to 35 per cent. (1 point for each 1 per cent.)	—	10
Silkiness:		
Very silky	5	—
Silky	3	—
Fairly silky	1	5
	Total ..	100

It is seen that, in the new score card, length and strength of staple are given equal points. This score card has given the utmost satisfaction throughout the period under review, and has been the agency by which an excellent selection from the Nyasaland variety was placed into general distribution in Serere County in 1921, and throughout the districts in 1922.

To resume, a plot of about two acres of special Sunflower cotton was bought from the Muganda agent at Kadunguru in December, 1911. The whole of this plot was "rogued" out, staples of less than

$1\frac{3}{16}$ inches being rejected and pulled up and burned, as well as any showing pronounced weakness of fibre. It was found necessary to go through the plot three times to ensure that no plants were missed, and a large number of plants had to be rejected. The remaining crop was picked and ginned by hand, and sufficient seed was obtained to sow an area of forty acres in 1912.

Individual selections to the number of eighty-five were obtained from the general crop of Sunflower during a tour of the county.

The results obtained from the forty-acre block in 1912 are interesting. Cultivation consisted of clearing the land of bush and grass, ploughing with heavy Invicta ploughs, cross ploughing, harrowing, and clearing grass roots by hand. As a result of deep cultivation on new land, the crop did not give a high yield. There was considerable production of wood, much bud shedding, formation of long internodes, and sparse bolling. The crop also suffered badly from insect attack, chiefly aphis, common boll worm and stainer beetle. The yield was only 410 lbs. seed cotton per acre. The following is a report on this cotton contained in the Annual Report of 1912:

"An examination of the above cotton disclosed a satisfactory improvement in the length and quality of the staple. The lint retained its silkiness and strength, and the average length was increased from $1\frac{1}{8}$ to $1\frac{1}{4}$ inches. Staples of less than 1 inch were rarely to be found, which is remarkable in view of the fact that large numbers of very short staples were found in the previous crop."

This cotton formed the basis of a change of seed throughout the country in 1915.

The seed from the eighty-five individual selections mentioned above was sown in small plots covering an area of about five acres. This crop was fairly successful, although insect pests were prevalent after some heavy rainstorms in August. When the first bolls opened the whole area was "rogued," every plant being examined, and a record kept of the number of plants rejected from each plot, in order to get the percentage of impurity in the strain. When the first examination was concluded, it was found that twenty-one plots out of the total of eighty-five had come up to the standard, as laid down in the first score card—*i.e.*, staples of less than $1\frac{1}{4}$ inches were rejected. This unfortunately entailed the rejection of some of the most robust cotton with staples of $1\frac{3}{16}$ to $1\frac{1}{4}$ inches, which would not have happened had the second score card been in use.

The twenty-one plots referred to were carefully rogued three times, and all inferior staples were pulled up and burned. The first pickings from the plants which remained were kept separate, ginned by

hand, and produced seed sufficient to sow a forty-acre block in 1913. The staple averaged 1$\frac{3}{8}$ inches in length, and percentage of lint 31 per cent. (office test). Some individual selections were made from this crop for use in the following year.

The crop in 1913 was successful, the yield per acre was 567 lbs. seed cotton, average length of staple 1$\frac{3}{8}$ inches, strong, silky, and fairly regular, ginning percentage over whole crop as ascertained at the ginnery, 29·5 per cent. A sample of seed cotton forwarded to the Imperial Institute received the following report: "This cotton is of excellent quality except for a little irregularity in strength. Length of staple 1·5 to 1·7 inches. Ginning percentage 28·4 per cent."

The above cotton formed the basis of a change of seed throughout the country in 1916.

The year 1916, with its floods and low temperatures, proved a disastrous one for the cotton crop in Teso and Lango Districts, and the above improved type did not get a fair chance. In subsequent years it gave better results, but there was a distinct tendency towards weakness in fibre, and a greater degree of immature and stained lint due to pests and diseases, and it has been our experience since then that extra long staples are more susceptible to insect attack than the shorter staples.

In the Busoga District of the Eastern Province and in the Buganda Province this type has given better results, and is still being grown successfully.

Another American Upland long-stapled variety named Allens was experimented with in the years 1910, 1911, and 1912, the seed being imported direct from America. This variety gave excellent results in the first three years. In 1913 the seed was distributed throughout the Teso, Lango, and Bukedi Districts, but the resultant crop showed marked deterioration in quality, the lint being brittle and weak. This weakness was held to be due to a long dry spell of weather during the period of lint development in the boll, which occurred in August and September of that year, the bulk of the crop having been early sown, and which probably affected the oil content in the fibre, and the thickening of the cell walls, making it brittle.

The improved Sunflower variety grown that year in a restricted area in Serere County did not appear to be affected by the climatic conditions referred to, and so it was decided to withdraw the Allens and continue with the Sunflower.

The Allens variety has been in continuous experiment on the stations since 1913, but has not developed again the weakness referred to. None of the selections, however, have given entire satisfaction,

and it has not been possible, so far, to put into general distribution an improved type of this cotton.

In 1915 a small quantity of seed was received from Nyasaland, and was sown in a quarter-acre plot late in the season. The crop proved a most successful one for a new importation, the plants being of a robust type, with strong fruiting branches, carrying numerous bolls of a large size. The yield per acre was 601 lbs. seed cotton, and percentage of lint 30·34 per cent. An examination of the lint, however, disclosed great irregularity in the length and quality of the staple. A few staples of $1\frac{3}{16}$ and $1\frac{1}{4}$ inches were found, but the majority were about 1 inch and under, the lint being strong but very coarse. A number of individual selections were made, and were sown in progeny rows the following year. Out of thirty-two selections only three were retained for further experiment—viz., N.30, N.31, and N.32, with staples of $1\frac{3}{16}$ to $1\frac{1}{4}$ inches, and chief characteristics: heavy yield, even distribution of lint on seed, large-sized seed, high lint index, and good strength of fibre.

Further trial in subsequent years proved N.32 and N.30 to be the most successful. These selections will be referred to later.

During the summer of 1914, a visit was paid to the office of the B.C.G.A. in Manchester. The latter very kindly arranged conducted visits to one or two of the spinning mills which used Uganda cotton, and also arranged a meeting with one of the principal firms of brokers dealing with our cotton in Liverpool. The spinners' and brokers' remarks on Uganda cotton are interesting:

The spinners, who were spinning Brazilian alongside Uganda cotton, had no fault to find with the latter; it was cleaner and less "wasty" than the former, but the staple was shorter and less regular, and for that reason they were paying 1d. to $1\frac{1}{2}$d. more for Brazilian. The spinner wanted a longer and finer staple, and larger and more constant supplies of the raw material.

On the other hand, the brokers commented adversely on our staples, averring that they were becoming too long and weak, and that cotton of this nature commanded a very limited market in Lancashire. They advised the writer to concentrate on the production of a medium $1\frac{3}{16}$ to $1\frac{1}{4}$ inches staple of good strength and regularity. As the latter advice coincided generally with the conclusions drawn from our experience of the crop, it was resolved to adopt it in future work in Uganda.

Followed the war period of 1914-18 with its waves of trade depression and revival, and general corrosive effect on a new industry in an outlying part of the Empire, such as the cotton crop in Uganda.

That the industry survived the vicissitudes of the war and its aftermath is due in large measure to continual propaganda and demonstration work by the agricultural and administrative staffs of the Protectorate, unfettered competition in the purchase of the crop, and the establishment of markets and ginneries throughout the country to deal with the crop.

The years in question were not without a beneficent effect upon the industry: the native grower learned that the cotton crop, like most other crops, is subject to violent fluctuations in price, and that he must be prepared to meet such fluctuations with a philosophical mind. It allowed the selector time to take stock of the quality of the crop throughout the country, to remedy defects and to retain that control over the seed supplies which is of such supreme importance in a new industry, and which would have been rendered more difficult had there been a continuous boom in cotton.

To return to the main subject of this review, after four years' work at Kadunguru, of which the last (1915) was the most successful, it was decided that the latter station was untenable from a health point of view, and early in 1916 the headquarters were removed to the new administrative station of Teso District at Soroti, and a site for the experimental station was selected three miles from Soroti, and designated the Simsa Station.

The soils around Soroti are light, sandy, and not very fertile, and that of the chosen site was no exception to the rule, but the best available, with a never-failing water supply, and suitable short-grass grazing for cattle. It was hoped to increase the fertility of the soil by the ploughing in of leguminous and other crops, and by applications of rich composts of cow dung, cotton seed refuse, and other débris to the soil. The latter was tried with good results, but has been supplanted by green manuring, as the latter was found to give equally good results, and materials for composts were not always easy to get.

This station was unfortunate in getting three bad cotton years to begin with, including the famine years of 1918-19. The first crop of cotton was sown in May and June, 1917. In these months torrential rains swept over the station, causing serious denudation of soil on the newly ploughed land, and much resowing of seed. A severe hailstorm in August and severe drought from November 8 onwards completed the discomfiture of the crop, which yielded only 148 lbs. seed cotton per acre.

The year 1918 was an exceptionally dry one, with a fall of 43 inches of rain against an average of 57 inches for the previous four years.

In this year the selection N.32, referred to above, came into prominent notice, as it surpassed any other variety grown beside it in hardiness to climatic changes and resistance to pests and diseases. This selection fulfilled in many respects the qualities required by the ginners in Uganda and the brokers in England. In habit it was a robust type, erect, with large erect basal branches and short sympodia. Large bolls and high yield per acre. Lint fine, silky; medium length—average 1 $\frac{3}{16}$ inch, very strong and very regular. Ginning percentage high—average 31 per cent.

In 1919 N.32 was grown as the main crop on the newly opened Kumi Station, and gave good results.

In 1920 it formed the main crop on the newly opened Serere Station, when a field of forty acres gave an average yield of 590 lbs. seed cotton per acre. In 1921 it was grown by natives in the Kadunguru segregated area, the total area sown being about 2,000 acres, and the results again excellent—the natives being pleased by the higher yields, and the local ginner by the higher ginning outturn. In 1922 the seed was distributed to natives throughout the Teso and Lango Districts, and since then it has been grown there, and also in other parts of the country. It is interesting to note that this N.32 type has steadily improved in quality in general cultivation, and that to-day it is commanding a premium up to 550 points on American Middling.

An excise tax on cotton was introduced by the Uganda Government in the year 1919, with the original object of raising a fund for the purpose of pushing cotton development. From the first year's collection of this tax, funds were set aside to build and equip two seed selection stations—one in the Buganda Province, and one in the Eastern Province.

After due consideration, a site for the new station in the Eastern Province was chosen at Serere, in the place originally selected by the writer in 1911, and the work of clearing began on January 1, 1920.

In laying out both the Simsa and Serere Stations the experience gained at Kadunguru was brought into action—*e.g.*, the necessity for wind breaks across the direction of the prevailing winds, and the division of the land into blocks of suitable size for cultivation by ox-drawn implements; drainage and prevention of soil wash were also carried out with good results.

Permanent buildings were erected and completed at Serere in 1920-21, consisting of a dwelling-house for the Agricultural Officer, an office and laboratory, and a storehouse, workshop, and tool store, also a temporary wattle and daub house for the Assistant

Agricultural Officer. The office and laboratory were equipped with the necessary furniture and instruments for the work of seed selection, and the workshop was fitted for carpentry and blacksmithing for general repairs to implements, etc.

After having been housed in temporary buildings of grass roofs and mud and wattle walls for ten years, during which, in September, 1919, the house and office with most of the records were destroyed by fire, the work of selection was at last housed and equipped in a manner worthy of its importance in the cotton industry of the country.

Throughout the whole period of thirteen years the writer has been responsible for the work, and during the first eight years of it he carried on single-handed with the help of a few trained natives. Since 1920 an Assistant Agricultural Officer has been in charge of the plantation work at Serere, and has rendered valuable assistance in the work of seed selection.

In 1920 the Uganda Government consented to a visit by the writer to the Sudan and Egypt, to get an insight into the methods of seed selection and research work being carried on in these countries. The visit took place in November of that year, and resulted in the adoption of some improvements in the work of selection in Uganda, notably in the methods of recording, a new record card being adopted with good results.

From 1921 onwards the procedure adopted in the production of new and improved types has been as follows:

First year: single rows 70 yards long, from individual plants selected the previous year.

Second year: quarter-acre plots from ten best productions of the previous year.

Third year: plots of three acres each from the three best productions of the previous year, with comparative test rows in different parts of the plantation.

Fourth year: main crop on the plantation, and test areas in different parts of the districts, from the one selection which has proved superior to the others.

Fifth year: segregated area of about 2,000 acres under native cultivation.

Sixth year: general distribution throughout the district.

By adopting the above procedure, which may seem a slow and tedious one, there is little danger of any new production being placed into general distribution without careful testing, and having its worth proved through all vicissitudes of climate and soil, without which no new variety or selection should be introduced into this country.

Owing to the fact that there are practically no European growers of cotton on a large scale in this province, the work of propagation of new strains has been rendered a matter of some difficulty, which can only be overcome by the establishment of seed farms in each district, where new strains produced on the Research Station can be tried and propagated. However, the development of seed farms of requisite area is faced by the most difficult problem in this country to-day—viz., labour, and there is little evidence to show that the problem is likely to be solved in the near future, as far as plantation work in the Eastern Province is concerned.

The Serere Station, like the Kadunguru and Simsa Stations, has not escaped the reactions following on the opening up of new land to cultivation in this country. In 1920 surprising results were obtained from the main crop of selection N.32, as stated above, cultivation having been done with Invicta ploughs and drag harrows. In the following two years disappointing results were obtained. In both years a disease manifested itself on the earlier sown cotton, which ultimately spread to the whole crop, causing a partial crop failure. The cause of this failure was considered to be partly due to physiological causes, but chiefly to a disease organism, which attacked the main stem and secondary growth, causing blackening of the stems, die-back on the branches, and death of buds and bolls. The crops of 1923 and 1924 were not affected by the above condition, and satisfactory yields were obtained.

Amongst the whole cotton crop of 1922, which extended to about seventy acres, a three-acre plot of selection N.17 stood out prominently in resistance to the prevailing disease. This selection was derived from a plot of N.30, referred to earlier in this review, grown on the Simsa Station in 1919. The progeny of this individual selection had given good results during its three years' trial. It combined all the good qualities of N.32 with a longer and finer staple, and appeared to be an improvement on the latter in every way.

Another selection, which had done well since its first selection as an individual plant in 1917 at Kadunguru, was N.21, and a progeny of N.32. This was a heavy yielding strain, but less regular in staple than N.17. It was decided to grow the two, N.17 and N.21, together on the station in 1923, in order to judge and evolve the more suitable type for distribution throughout the district. Plots of ten acres of each were sown, and, after careful observation and examination of the growth of the crops and the lint characters, it was proved that N.17 was the superior cotton of the two.

The main characters of the N.17 type are lint fine and very silky;

staple length 1¼ to 1$\frac{5}{16}$ inches, strong and very regular; ginning percentage, 31 per cent. In addition, by reason of its habit, productivity, and resistance to diseases, it is considered to be a distinct advance on any cotton grown so far in Uganda.

The above cotton has been tested in different parts of the Teso and Lango Districts, as well as forming the main crops on the Serere and Simsa Stations during 1924, with satisfactory results. Heavy yields were obtained from all the areas sown, and sufficient seed has been collected to sow a segregated area of 3,000 acres in Serere County in 1925, from which seed will be available for wide distribution in 1926.

A 5-lb. sample of ginned cotton from N.17, grown in 1923, was forwarded to the Empire Cotton Growing Corporation to undergo a spinning test. Their report is as follows:

"The sample N.17 was put through spinning test F., in which it was compared with Memphis extras. The standard counts spun in this test are:

"1. 62's twist with 28·5 turns, from 11½ Hk. roving.

"2. 64's twist with 28·66 turns, from 11½ Hk. roving.

Yarn (Nominal Description).	*Mean Result.*		*Memphis Extras.*	
	62's Twist, 28·5 Turns.	*64's Twist, 28·66 Turns.*	*62's Twist, 28·5 Turns.*	*64's Twist, 28·66 Turns.*
1. Observed counts ..	66·8	64·5	—	—
2. Observed twists ..	30·82	29·82	28·0	31·9
3. Observed lea strength (lbs.)	26·2	31·1	—	—
4. Lea strength at nominal counts (lbs.)	27·2	26·9	—	—
5. Ballistic strength at nominal counts ..	37·9	35·2	40·0	36·4
6. Single thread strength (grams)	97·3	93·6	105·7	98·6
7. Variability per cent.	10·3	10·4	8·7	8·4
8. Extension per cent.	4·77	4·4	5·9	5·5

Remarks.

This is a good, lustrous, and very desirable cotton. The yarn spun from it was strong and regular, and very clean (*i.e.*, free from nep, etc.), for carded qualities.

An appreciable increase in the value of Uganda cotton is anticipated, without undue optimism, when the improved type N.17 is established in the cotton fields of the Uganda Protectorate."

[While, if this work were to be commenced at the present time, it would probably be conducted upon somewhat different lines, this paper gives an historically valuable account of what was actually done—a work whose important results are to-day visible in the success and good prices of Uganda cottons.—Ed.]

THE RELATIVE IMPORTANCE OF INSECT DAMAGE AS A FACTOR IN INHIBITING THE PRODUCTION OF COTTON IN SOUTHERN NIGERIA

BY

A. W. J. POMEROY, M.B.E., F.E.S.

The development of cotton-growing in Southern Nigeria has been the subject of considerable investigation by the Agricultural Department for nearly fifteen years, but owing to the varied and complex nature of the problem, no successful and practical solution has been arrived at to date. Many useful data have been compiled, however, especially with regard to the entomological phases which constitute the principal theme of discussion in this article, which refers to Southern Nigeria only.

I suggest that there are three essential points which must be considered with regard to the possibility of the native farmer in Southern Nigeria growing cotton for export on an increasing scale, and these are: the cost of production, which includes the labour spent and the actual loss to the crop from various causes; the cost of transport to the local buyer; and whether the native considers he is receiving a sufficiently attractive profit.

Perhaps this general statement may savour of a platitude, since, at first sight, it might be applied to the production of any crop, but the difference in this case lies in the fact that the native farmer at present is not by any means dependent on cotton even for his luxuries, while in many other parts of the world the cotton-grower largely depends on this particular crop for his livelihood.

Varieties of cotton, which may now be considered almost indigenous to Southern Nigeria, have been grown by the native for many years and have been exported, subject to certain fluctuations, to an increasing extent. This increase, however, has not been sufficiently rapid, nor has the total annual amount exported been such as to warrant much hope that the yearly export will rank other than as a very small item compared to that of other cotton-producing countries, unless some special and successful effort be made to increase the production.

When deciding that an effort might be made to increase the output of cotton, on the evidence available that it is already grown to a certain extent, and that both the necessary areas and labour are available for extension, three important points must be taken into consideration: whether the local varieties can be improved and the output increased, whether a suitable and superior exotic variety can be successfully introduced on a considerable scale, or whether a combination of both methods must be adopted.

If it is decided that actual growth conditions are equally favourable to both exotic and indigenous cottons, the problem remains for the entomologist and mycologist to ascertain which variety is the most profitable, when the loss from insect and fungus damage is subtracted.

On the other hand, if growth conditions are unequal, then it becomes necessary to determine if it is even then more profitable to grow an exotic variety, owing to the higher price paid for the product, after deducting a certain loss from both environmental and mechanical causes. Further it is necessary to ascertain if there is a sufficient margin of difference between the two types in favour of the exotic variety, to warrant the hope that the native farmer can be induced to undertake a new project on a sufficiently extended scale.

From my own and other workers' observations on American and native varieties of cotton in Southern Nigeria, there appears little doubt that the American varieties are more intensely affected by insect damage than the native, and the latter very much more affected by various bacterial and fungus diseases. Both laboratory and field experiments have proved that American cotton exerts a greater chemotropic action on insects generally than the indigenous varieties, and experiments have proved that there is a greater migration of *Dysdercus* to American cotton than native, when both are grown side by side.

From evidence to date, the reasons for this greater infestation by insects seems to be the greater intensity of the flowering periods of the American cotton, and the more succulent nature of the bolls. On the other hand, it must be remembered that the effects of insect attack are often confused by natural shedding of bolls due to physiological causes, and the vital point at issue is the value of the ultimate yield of clean and sound lint which is produced. There seems little doubt that the percentage of stained and aborted lint is generally higher in the native cotton than in the American variety Allen, and this seems readily explained by the fact that with the longer developmental period the chances are greatly increased of bacterial or fungoid infection following after, or being introduced by, insect attack.

The ultimate effect of the attack by various lepidopterous larvæ, known as boll-worms, is generally greater on the native than on the Allen, and again the longer developmental period of the former increases attack by insects affecting opened bolls, since access is gained during the intervals of picking.

The longer the developmental period of the cotton crop, the greater the chance of succeeding generations of insects and fungoid diseases attacking it; consequently, it must be clearly proved that a cotton which has a slow growth and continued boll development as one of its chief characteristics has a correspondingly profitable immunity from such loss, or an adequately compensating lint value.

Has the native variety commonly grown in Southern Nigeria these redeeming features? I consider it has not. Firstly, a much less price is paid for the native than the American variety; secondly, the cleanliness and quality of the lint is greatly inferior; thirdly, the long developmental period prevents the enforcement of a satisfactory close season which can be obtained by a quick-developing variety. A strain may be developed, by careful selection, which will be an improvement on the present, but unless an area is exceptionally well controlled and local strains eliminated, the improved variety will inevitably revert to the type already established and evolved through centuries of cultivation.

The native has been accustomed from time to time to grow the native variety as a perennial crop, a procedure which inhibits any control of insect pests; and, in addition, the ground is occupied by a crop which is giving a meagre return for its existence. It is true that from the natives' point of view a small profit is being made with no effort but that of picking, but from a broad economic point of view the loss by increased pest infestation, deterioration in lint, quality and expenditure of agricultural land, far outweighs any material advantage gained by such a policy.

A district in which Allen is introduced can be more readily controlled, since the dissimilarity between the native and American foliage facilitates inspection; the growth rate is such that a close season can be enforced; and the period over which transport is carried on can be accelerated, owing to the fewer pickings required.

Can a quick-growing American or exotic variety be grown profitably by the native? I suggest that the issue seems to have been confused in the past by two important factors: firstly, the methods employed to introduce a new crop to an ultra-conservative farmer population; secondly, that there appear to be certain years in which cotton in Southern Nigeria in varying areas seems to fail as a profitable

crop. The cause of this phenomenon is yet being investigated, but I suggest that from evidence to date it would seem that a more rapidly growing and higher priced exotic cotton would pay in the long run a greater average profit than the present local variety; but whether such a project can be introduced, owing to the risk of a failure from the introduction taking place in an adverse year, remains to be seen, since it would be found almost impossible to convince the native that a longer viewpoint was the most profitable.

Since intensive experimental work has been carried on, an adequate number of comparable records are not available to show whether the native cotton can survive the adverse conditions sufficiently to balance the greater profit on the Allen in favourable years; and unless it can be shown during the next adverse year that the native can give a profitable yield, all other considerations point to Allen, or a similar quick-growing exotic, as the most desirable variety.

If close-season measures are to be enforced, they must be done thoroughly. On an area around Moor Plantation these have been carried out with increasing efficiency for two seasons, and the result has been a fair yield. Certain pests have been undoubtedly reduced, as proved by simultaneous experiments in other areas. It is not yet considered that enough proof has been obtained to warrant a statement that these measures have been responsible for the crop successfully developing, and until this area can show an increase over the surrounding area in an adverse year, or a steady increase over a period of years, the critics of such measures will not be convinced.

I suggest, however, that such basic measures as have been tried and found effective in other cotton-growing countries will probably be found applicable, and that the valuable experience gained to date of insect control on cotton should be tried on a sufficient area, and over a period, which will give a proper test of their value when applied to Southern Nigeria.

COTTON AND GUILE

BY

J. C MAY

The Native Commissioner, a title shortened in Africa, that land of initials, into N.C., quenched the end of his cigarette by thrusting it into the dregs of his coffee cup, threw the stump over the low verandah wall, and rose from the breakfast table. Glancing mechanically at his wrist-watch he saw that it was a few minutes to eight, and passing round the corner of the house he took down his helmet from the buffalo head on which it always hung.

The morning sun had just climbed over the spur of the mountain at the back of the station, and the garden—stretching for a short distance in front of the house, filled with a mixture of tropical and English flowers—looked fresh and inviting. The N.C. smiled at himself for his pride in his garden as he walked rapidly along the path that led to his office and court-house a few hundred yards away. The station had been built in a truly beautiful spot; to the east the mountain, its wooded ravines blue-grey in the morning shadows, to the west a plateau covered with short green grass in which were dotted fine old trees, for all the world like an English park, in spite of the fact that it was situated in Central Africa.

Arrived at the office the native policeman on guard saluted smartly, and the N.C. entered the room in which he spent so many weary hours, in spite of all his efforts to get away from the station and travel in his district. A goodly pile of letters lay on his desk, for this was one of the two days in the week on which the mail carriers arrived, having half walked, half run, from headquarters fifty miles away.

Absorbed in his letters, an hour had sped quickly by when the N.C. was made aware of someone at his elbow by a deferential cough. "Well, Ben, are there many cases to-day?" "Yes, Bwana,* many," replied the native interpreter with a broad smile. "Right, we will attend to them," said the N.C., and rising, he passed through the native clerks' office on to the broad, low verandah at the end of the building. Here, on the edge of the verandah, a table covered with a Union Jack, on which rested the court books, a chair for

* Bwana in Central Africa is equivalent to Sahib in India.

the magistrate, and a long bench, constituted all the furniture of the court. On his appearance up rose two old gentlemen with woolly white hair and red fezes on their heads, who had been sitting on this bench. A courtly bow from each, and "Wanyile Bwana" conveyed to the N.C. their morning greeting. "Wanyile Kisokola, Wanyile Swewe," was his reply, for these were the two local headmen, Kisokola and Swewe, whose invariable custom it was, save when it was raining hard, to come and sit as assessors to the court in order that their opinion might be taken on points of native law.

On the ground below the verandah had been seated a crowd of from forty to fifty natives, the principals in the cases that would be brought before the Bwana, their relations and friends, and numbers of inquisitive people who had nothing to do and who had therefore come into the Boma (Government Station) to listen to the fun. The court is to the African native what the theatre, the cinema, and the countless other places of amusement are to the English public. Here you can sit, be amused at the lies of the contesting parties and their witnesses, and when bored by them you can chat to your friends.

The arrival of the N.C. had been the signal for a general rising. "Wanyile Bwana" echoed from mouth to mouth, and the crowd then sank once more on to their haunches. The attendant police cleared a space immediately in front of the court table, the principals in the first case stepped forward, and Ben, the interpreter, took his stand on the right of the magistrate.

The first case was called and the plaintiff advanced and tendered a summons form. Ben handed it to the N.C., who gathered therefrom that Mwasakulu desired to claim 4s. compensation from Sefu on account of cotton taken from the plaintiff's garden. Asked through the interpreter if he accused Sefu of stealing the cotton, he answered: "Oh no, he just took it." Mwasakulu was then requested to state his case.

Having cleared his throat, stepped back a pace to give himself further freedom for appropriate gestures, and thrown his long black toga-like cloth, trimmed with a narrow white margin, more tightly over his left shoulder, he commenced. The N.C. listened carefully, glancing keenly into the plaintiff's face from time to time, at others eyeing the crowd attentively as occasionally an indrawn breath denoted a point made or a palpable exaggeration, and this was the story unfolded.

"Long ago," said Mwasakulu, "Maso, Sefu's father, and I were as brothers, and soon after my daughter Kaboneke was born he

came to me and suggested that his son Sefu should marry her. After discussion as to the price to be paid for my daughter we agreed, and Maso promised to pay one bull, two cows, and three heifers for Kaboneke. In addition Sefu was to do the customary work in my garden when he was more fully grown. The years went by and Kaboneke grew near to marriageable age. By now Maso had paid me one bull, a very small one; one cow, a very old and thin one, and incapable, Bwana, of bearing further calves; and four young heifers. Then came the time when you said, Bwana, that if we planted cotton you would buy it from us so that we could have money, and that the young men could also make money by carrying the cotton to the ginnery. So I sent my wives to the Boma for seed, and you gave it them. Then I called Sefu and told him to come and hoe in my garden and make the ground ready for the cotton. This he did, though unwillingly, and we sowed the cotton as you instructed us and it grew up. The dry season came and the cotton ripened, and I would look on my garden and think that I should get money by selling this cotton to the Boma. Then one morning I went to the garden with my wives and my two children to pick the cotton, for all was now ripe. But, behold! when I got to the garden all the cotton was gone. There was nothing there whatever, it was empty as a mission grave!"

At this point he paused with a dramatic gesture. Catching a movement to his left the N.C. saw Kisokola nudge Swewe and whisper to him, and at the end of a few whispered words they both chuckled with amusement at some hidden jest.

"Then I said to my wives: 'Who can have taken our cotton? Yesterday it was all here!' My wife Kakombe said: 'It is Sefu; he helped to hoe the garden and to plant the seed, and now he has taken the cotton.' Then I went to Sefu's village and asked where he was, and they told me that he had gone to the market with the cotton, and that Mwatolo and Kito had helped him to carry it. So I came to the market and found Sefu and asked him why he had done this. He said: 'It was I who hoed the garden and planted the cotton, and I have taken what I planted.' Now by our custom the son-in-law must work for his father-in-law, and the crop that is reaped belongs to the father-in-law. Therefore I claim the money that was paid for the cotton."

This appeared to have exhausted Mwasakulu's eloquence; Sefu was accordingly requested to state his side of the case. Said Sefu: "Mwasakulu's daughter was promised to me, and my father paid all the bride price. Mwasakulu has received one bull, two cows, and

three heifers, and Ponelo,* the cow that Mwasakulu states was too old to bear further, has since had two calves.

"I then went to Mwasakulu and asked him for one of these calves in order to pay for another wife. Mwasakulu beat me and drove me away. So when the cotton was ripe I went and picked it and sold it for 4s. See, here is the ticket that I received in the market."

The N.C. considered for a moment. "Has Mwasakulu's daughter commenced to live in your hut?" he asked of Sefu. "No," was the reply, "her father will not let her." "Is she now of marriageable age?" enquired the N.C. of Mwasakulu. "Yes, but——" The N.C. held up his hand to signify one thing at a time. "Who is Mwasakulu's village headman?" queried the magistrate. An old man in the crowd stood up, and in answer to a question stated that two calves had been born since Mwasakulu received Sefu's cattle. One had, however, died. The N.C. smiled; the ineradicable habit of every payer of cattle of counting all calves both living and dead, and the easy forgetfulness of the payee of the birth of all calves, had always to be borne in mind when hearing cases concerned with cattle.

Having ascertained that Mwasakulu had in all ten head of cattle, a statement to which Mwasakulu agreed with a self-satisfied smile, the N.C. announced his decision.

"By native law the calf that remains to Ponele should be given to Sefu—for you, Mwasakulu, have received the full price and have a number of cattle—and by your custom Kaboneke should now go to Sefu's hut. Sefu has done wrong in taking your cotton, but he has saved you and your family the trouble of picking it and taking it to the market. He will pay you 6s.—the 4s. he got for the cotton, and 2s. in addition."

Everyone seemed pleased, the 6s. was handed to Mwasakulu, and Sefu walked away through the crowd beckoning with his chin to a young girl who was sitting on the outskirts. This young lady, who carried a mat in her hand, and was no doubt Kaboneke, followed him with a smile, while Mwasakulu, after a half-hearted attempt to make the Bwana believe that he ought not to have to hand over the calf to Sefu, retired to a space next to his village headman.

The next case was called, and the morning wore quickly away as the magistrate dispersed patriarchal justice, occasionally asking Kisokola and Swewe what they thought to be a fair decision in a complicated case.

* It is the custom of some of the cattle-owning tribes to name their cattle and to talk of them much as if they were human beings.

"And now, Swowo, what was the joke during the first case?" smilingly asked the N.C. "It's no use your pretending that you did not poke Kisokola in the ribs and chuckle together over some small point. I have known you too long, and have heard too many of your stories not to know that you have a tale worth hearing of which the case reminded you." To his surprise both headmen seemed rather embarrassed, and looked at each other as if trying to invent some story on the spur of the moment that would serve the purpose of staving off the N.C.'s curiosity. By this time the crowd had melted away, and the headmen's own followings of councillors and attendants had moved into the shade of a large fig-tree near the police lines, and were gossiping together.

"Bwana," said Swowo suddenly, after a pause, as if he had made up his mind at last after some difficulty, "I will tell you, partly because you will be certain to find out sooner or later, because" (with a sly glance) "you are always asking questions, and partly because it is good that you should know our customs. But I can only tell you on two conditions. The story concerns the Mission, and you must promise not to tell the Fathers. The story also concerns a custom of ours, which I consider a good custom, and you must promise not to set your face against this custom." "You ask too much," returned the N.C. "Have I ever set my face against any of your customs that are good? I cannot promise, for I am put here by the Government to look after you, and to see that good and not evil is done in the district. Again, I think highly of the Fathers, who help you in sickness and look after your children." "Then I cannot tell you, Bwana," declared Swowo. But Kisokola intervened, saying, "The Bwana shall judge if the custom is good or bad, and if hurt is done to the Mission by its observance." "Who shall tell the Bwana?" said Swowo, inhaling a deep breath from the cigarette which the N.C. had given him at the beginning of the conversation. "You," replied Kisokola; "you speak the better of us."

Swewe therefore began: "Bwana, as thou knowest, all tribes believe that ill-fortune is caused by the deeds of men, either the dead or the living. If wrong is done in the village, our ancestors are angry, and ill-fortune falls upon us. The Wahanga to the north of us believe that ill is caused by living persons, and before the Europeans came many were killed, or submitted to the ordeal, that evil might be averted and men proved to be innocent or guilty. Even now, since the Europeans have come, a few die yearly in secret. It is not so with us the Walabo. Long ago it was so, but when Isoko

led our forefathers up into this country he said that misfortune was caused not by the living, but by the envy of the dead. Therefore it is our custom when ill befalls a family or a village to go to the 'Singanga,'* and to consult him regarding that which has befallen. Suppose that Kissaki, the little daughter of Kipata, has fallen ill. Her mother goes to the Singanga; she tells him of the illness, and desires him to consult the spirits. He fetches his divining board and the rod that is rolled upon it. 'Say then,' says he, 'whom dost thou suspect?' She then mentions perhaps the child's grandfather, who cared not for her greatly before he died, when she was still little. The Singanga rolls the rod up and down over the board with the palm of his hand. It does not stick; the illness is not caused by the grandfather. "Mention one further," commands the Singanga, and perhaps the mother names her own grandmother. The rod sticks not; it is not she. The great-uncle, Kapakapa, is perhaps named next; the rod sticks beneath the Singanga's palm; he has discovered the cause of the illness.

"After paying the Singanga, the mother goes away and tells her husband and neighbours. That night they go to the grave of Kapakapa and dig up his body and carry it away into the bush. There it is burned, and a fire is lit in the grave to burn up any bones that may have remained. Then the child grows better, for the envy of Kapakapa has been ended.

"Now long ago, as the Bwana knows, the Fathers came here and they began to teach the people, and they said that those that died in their faith should be buried in a piece of ground near the church. They allowed the relations to bury the bodies according to our customs, and we, therefore, did not mind much. Then they planted flowers on the graves, and marked them carefully with stones.

"After many years there were ten graves near the church, and the Fathers tended the flowers they had planted on those graves. Then one day one of those that were buried there was named by the Singanga, and that night the relations went and dug up the body and carried it away and burned it. But next day the Fathers were very angry, and sent for the local headman and said that the relations had done very wrongly, and had offended their God. Then the villagers consulted amongst themselves, for they said: 'Probably we shall want to dig up the other bodies, and what are we to do—more will be buried in the garden round the church, and what shall we do when we wish to dig them up?' Then Phillipo died in Sitara's

* Witch-doctor, though the term may be used of those who do not deal in unlawful magic.

village near the mission, and his relations took his body quickly and buried it in a secret place; for he had been a preacher for the mission, and the people knew that the Fathers would want to bury him near the church. At this the Fathers were very angry, and their Bwana Mkubwa* came down from near the Lake and called us all together and said that the digging up of the dead was a bad custom, and that it must cease. So we were afraid and consulted the wise men of the district, and for three days they considered the matter amongst themselves. At the end of that time they went to Sitara and said: 'We have found a path out of this forest. The Likase is now in flood and will soon be as high as it ever is during the rains. Let four or five large trees be felled into the river as soon as the water covers the large rock in the river near the mission. These trees will be caught by the fish weirs that stretch across from this rock, and the water will flow over the bank and will flood the land near the church. Then let the people dig up the bodies that are there, replacing the earth and flowers carefully, and carry them away and re-bury them. As for those that die henceforward, they shall be removed on the same night that they are buried, and the Fathers will know nothing!' Then the villagers chose six large trees and cut them nearly through in order that they might be ready, and the fish weirs were strengthened so as to hold the trees when they floated down-stream. As soon as the river was bank high, Sitara sent men quietly one night to the church, and they dug up the bodies as quickly as possible and carried them away, while others filled in the graves and stamped down the earth and remade the mounds and replanted the flowers. Then, towards dawn, the signal was given for the trees to be felled, and they were swept down to the fish weirs, and the water flooded the whole of the land near the mission for two or three weeks.

"Therefore I laughed, Bwana, to Kisokola when Mwasakulu said that his garden was 'as empty as a mission grave,' for although the Fathers look after the graves near the church most carefully and plant flowers like those that the Bwana has planted along the path from here to his house"—"Yes, violets," said the N.C.—"on the graves of those that are newly buried, those graves are empty; yet the Fathers know it not, and therefore are not angry. The Bwana will not tell them?" "No," said the N.C., with a sigh of relief that he would have no cases of trial by ordeal as far as the Walabo were concerned, "the Bwana will not tell them."

* The Bishop.

A NEWCOMER'S IMPRESSIONS OF UGANDA

BY

A. B. KILLICK.

UGANDA, although a comparatively small Protectorate, varies enormously in climate, vegetation, and peoples; in consequence conditions differ greatly from district to district. In setting down my impressions as a newcomer, I therefore confine my remarks solely to the Teso district to which I was first appointed.

Topographically, this district consists of slightly undulating plains, intersected by swamps. Here and there arise great granite rocks, some 150 to 200 feet in height. The whole is covered with long grass and bush. Owing largely to the density of the population there is, unfortunately, no big game, a great disappointment to one who expected to encounter a lion or an elephant at every turn. There is much stagnant water and marsh, and in consequence plenty of mosquitoes. The first few months were very hot indeed, it being the dry season; hot days and hot nights, with often hot winds. Now, however, the rains have started and the days and nights are much cooler. Thunderstorms are very frequent and of a most terrifying intensity.

One of the most noticeable features is the number of really excellent roads throughout the district; a few of the main ones are metalled and capable of carrying heavy lorries; the majority, however, are native-made and maintained, good for light lorries, ox-transport, and motors. Transport facilities within the district are therefore excellent. Down-country communication is bad, though it is unnecessary, here, to go into details. The district will, of course, benefit enormously when the projected through railway service to the coast is completed.

The natives are a constant source of interest. They are still very primitive, especially in the outlying parts. Their language seems to consist of a succession of meaningless sounds; it is impossible to pick out the words. However, all the chiefs and many of the more educated natives speak the official language, Luganda, many also Swahili; it is remarkable how a comparatively uneducated native will be fluent in three or more languages. One of the first duties of a newcomer is to acquire a sufficient knowledge of Luganda, so as

to understand and be understood by the natives. Until then, unless he is lucky enough to be provided with an interpreter, he is useless.

The ordinary peasant, or "mukope," male and female, wears little or nothing in the way of clothes; the man perhaps a pair of shorts, an old shirt, or a blanket; the woman usually a single piece of cloth extending from her waist to her knees. The chiefs, however, are usually very expensively clothed; a pair of trousers, navy blue for choice, over that a cotton or silk "kanzu" (a long garment extending from the neck to the ankles), and then a well-cut coat. Brown shoes and a sun-helmet, usually adorned with a feather or cheap jewel ornament, or a soft felt hat complete their attire.

The Saza, or county chiefs, of whom there are four in the district, have motor-cars; many of the Abagombolola, or sub-chiefs, have motor-cycles, and ordinary push bicycles are almost too numerous to count.

The natives dwell in family communities, a collection of small wattle huts, grass-thatched, the thatch reaching very low down, leaving but a very small doorway; scattered around are their small food stores, round mud and wattle structures, built off the ground, and covered with a removable lid. The whole is surrounded by a euphorbiaceous "boma," or fence.

These days the native is, from his own point of view, a wealthy man. He grows his own food, several kinds of small grain, helped out by sweet potatoes; they all have their plot or two of cotton, bringing them in from 30s. to 70s. Many have now bought ploughs, the advantages of which they have been quick to realize, otherwise their only implement of cultivation is a very short hoe. Their expenses are very small: a poll-tax of 15s. per annum is paid by every male over eighteen years of age. The bulk of their money is probably spent on clothes. They have to pay very high prices for very inferior articles (many, regrettably, of foreign manufacture) at the Indian "dukas" or shops, which are to be found at almost every gombolola.

One immediately notices how very childlike they are, easily pleased and easily upset; one minute chatting and laughing, the next all shouting out over some grievance; on safari carrying their loads fifteen miles or more and at the end receiving a few cents, which they carefully count, and then probably go off to the nearest duka and spend them all on cigarettes.

Cotton.—The soil throughout the greater part of the district is very suitable for cotton, the acreage of which has increased by leaps and bounds during the last few years. The cotton season is now just over; the acreage last year was close on 90,000 acres as against

68,000 the year before. The total poll-tax population for the district is approximately 60,000, giving one and a half acres per poll-tax unit. The crop is grown in small plots a quarter to one acre in extent, in rows 4 feet by 2 feet—one plant per hole. Many of the chiefs, however, have much larger acreages. The seed is provided free. The bulk of the crop is sown in July, some being also sown in May, June, and August. The buying season opens December to January; in each county (of which there are four in the district) there is a cotton market, each consisting of twenty-five to forty stores, while scattered all over the district are twenty-four ginneries. Round about each buying post and outside each ginnery are numerous hawkers, around whom gather crowds of natives, eager to buy cheap blankets, clothing, sugar, soap, or cigarettes at greatly inflated prices.

The native brings in his cotton in bags, baskets, or blankets in loads varying from 15 to 100 lbs., all carried on his or her head, sometimes walking long distances. At the market or ginnery his cotton is weighed, and he receives his shillings and cents according to the price exhibited on a board. In most cases there is, unfortunately, little, if any, attempt made to grade the cotton as it is brought in; this is especially true at the beginning of the season, when there is a rush.

The yield at present is low, the average in 1924 being 307 lbs. seed cotton per acre. This yield is doubtless capable of a great improvement. New varieties, with better yielding and greater shedding-resistant powers, are being tested by the Agricultural Department. When the native realizes the advantages which accrue from better cultivation, and a satisfactory high yielding strain is introduced, it is not too much to expect that, while the quality of the cotton will be maintained and probably improved, the yield per acre will be doubled.

STOCKS

BY

JOHN A. TODD

To supplement the article on consumption given in the July issue of the journal, we now give the information promised in that issue with regard to stocks.

The various statistics relating to stocks may be grouped as follows:

1. The Liverpool Cotton Association issues *weekly* figures of the "Visible Supply," comprising stocks in Liverpool, Manchester, and London, and also in Continental ports, cotton afloat to Great Britain and the Continent, and stocks in U.S.A., Bombay, and Alexandria. These latter figures are mainly for American, Indian, and Egyptian respectively.

2. The Alexandria General Produce Association issues *weekly* figures of stocks in Alexandria, which represent the bulk of the stocks of Egyptian in Egypt.

3. The East Indian Cotton Association issues *weekly* figures of stocks held by exporters, mills, and dealers in Bombay, but these are, of course, only a partial statement of the stocks of Indian cotton.

4. The Census Bureau of the U.S. Department of Commerce has since September, 1912, issued *monthly* figures of stocks in mills (Invisible Supply) and public warehouses (Visible Supply) in U.S.A. These include foreign cotton, linters being given separately. At the end of the season a figure is also issued for stocks of American cotton and linters held "elsewhere" in U.S.A.

5. The International Cotton Federation has since 1905 published *half-yearly* statistics of mill stocks of all kinds of cotton throughout the world, including the Census Bureau figures for the U.S.A.

6. Various private and semi-official bodies in America publish *weekly* statistics of "Into sight," "Out of sight," and Visible Supply, the best known of these being the New York Cotton Exchange, the New Orleans Cotton Exchange (generally known as "Hester's figures," from the name of the Secretary, Colonel H. G. Hester), and the *Financial Chronicle.*

It will be seen that even with all these statistical publications the available data are by no means complete; in regard to American, for example, there is no information with regard to Visible Stocks outside

of America, Great Britain, and the Continent throughout the season, and even at the half-yearly periods, we get only the mill stocks for those countries. This, however, does not matter very much, because most of these countries do not consume very much American, the local consumption being confined mostly to local-grown cotton, and therefore the amount of their stocks of American cotton is not likely to be very large.

In regard to Egyptian, there are never any statistics of stocks in Egypt other than in Alexandria, but this also as a rule is not very material, as, except during the actual picking season, the bulk of the stock in Egypt is always in Alexandria. There was a time, however, at the end of seasons 1920-21 and 1921-22, when it was stated that a very considerable amount of cotton, amounting in one case to 1,000,000 kantars, had been retained up-country, and of this there was, of course, no statistical estimate possible. In normal times, however, this factor may be ignored.

In regard to Indian cotton the position is much less satisfactory, as there are no statistics in India other than those for Bombay above mentioned, and the lack of statistics of stocks in other parts of the East which use considerable quantities of Indian cotton is also a serious drawback. For that reason, it is probably hardly worth while to attempt a complete world's carry-over of Indian cotton.

Of all this mass of statistical information comparatively little use is made by the cotton trade as a whole. Practically the only statistics that appear regularly in the press and are discussed by the trade are the weekly Visible Supply statistics, and a detailed comparison of the various figures given from week to week by different authorities does not inspire great confidence in their accuracy. The Census Bureau's monthly stock figures are practically ignored by the trade, although as a matter of fact they do make it possible in conjunction with the other statistics available to get a pretty good review of the position and trend of stocks of American throughout the world.

At the end of each season most of the authorities above quoted, especially in America, issue a review of the position, the Census Bureau's statement of Supply and Distribution, and Hester's annual carry-over, being the most generally quoted in the trade. But as the latter's figures are published within twenty-four hours of the end of the season—*i.e.*, long before the Federation stock statistics come out—it is not known how he gets his figures of the world's mill stocks to include in his total.

In the writer's opinion, however, it is possible to get a much more complete and reliable review of the position month by month, both

TABLE I.—WORLD'S MONTHLY CARRY-OVER OF *AMERICAN* COTTON.

In thousands of running bales.

(Including linters in U.S.A., also Sea Island and American Egyptian, but not foreign cotton).

End of—	Stock and Afloat.		U.S.A.		Monthly Totals.	Federation	Half-Yearly Totals.	U.S.A.	End of Season Totals.	Hester.	Census Bureau.*	L.C.A.
	U.K.	Continent.	Mill Stocks.	Public Ware-houses.		Other Mill Stocks.[1]		Elsewhere.				Visible Supply.
1912, Aug.	508	406	786	556	2,256	1,305	3,561	350	3,911	—	—	1,201
1913, Feb.	1,384	1,270	1,898	2,251	6,803	1,459	8,262	—	—	—	—	4,052
Aug.	423	282	690	402	1,806	1,011	2,907	375	3,282	—	—	1,018
1914, Feb.	1,219	1,338	1,761	2,363	6,681	1,379	8,060	—	—	—	—	4,271
Aug.	627	480	687	562	2,365	—	—	320	—	4,564	—	1,523
1915, Jan.	1,076	1,142	1,581	4,746	8,545	—	—	—	—	—	—	5,565
July	1,238	753	1,401	1,830	5,321	—	—	850	—	7,701	—	3,200
1916, Jan.	785	585	2,012	4,675	8,057		—	—	—	—		4,457
July.	707	516	1,500	1,151	3,964	—	—	450	—	5,105	—	2,080
1917, Jan.	941	740	2,324	3,837	7,842	—	—	—	—	—	—	4,283
July	237	332	1,521	1,000	3,150	—	—	440	—	4,305	—	1,531
1918, Jan.	406	286	1,742	3,755	6,189	—	—	—	—	—	—	3,342
July	174	163	1,541	1,924	3,802	—	—	315	—	4,422	—	2,024
1919, Jan.	524	380	1,806	4,722	7,531	—	—	—	—	—	—	3,700
July	806	486	1,519	2,402	5,213	—	—	1,150	—	6,909	—	3,307
1920, Jan.	1,368	714	2,165	4,070	8,316	850	9,166	—	—	—	—	4,722
July	878	474	1,485	2,202	5,009	1,066	6,165	500	6,665	6,216	—	2,945
1921, Jan.	840	758	1,391	5,880	8,869	1,050	9,919	—	—	—	—	4,731
July	839	805	1,222	3,874	6,740	1,137	7,877	1,960	9,837	9,364	9,172	4,094
1922, Jan.	743	838	1,758	4,671	8,010	1,176	9,186	—	—	—	—	4,303
July	558	562	1,266	1,468	3,854	1,243	5,097	185	5,282	4,879	5,123	1,988
1923, Jan.	605	682	2,054	3,458	6,799	885	7,684	—	—	—	—	3,450
July	187	206	1,115	910	2,418	713	3,131	310	3,441	2,573	3,065	883
Aug.	123	207	816	1,131	2,277	—	—	—	—	—	—	914
Sept.	224	355	778	2,114	3,471	—	—	—		—	—	1,640
Oct.	320	478	1,119	3,409	5,386	—	—	—	—	—	—	2,587
Nov.	476	520	1,471	3,772	6,248	—	—		—	—	—	3,292
Dec.	643	558	1,680	3,534	6,415	—		—	—	—	—	3,406
1924, Jan.	742	555	1,678	3,006	5,981	815	6,796	—	—	—	—	3,196
Feb.	644	563	1,620	2,551	5,378	—	—		—		—	2,782
Mar.	529	592	1,537	2,057	4,715	—	—	—	—	—	—	2,365
April	451	496	1,365	1,559	3,871	—	—	—	—	—	—	1,942
May	349	416	1,180	1,162	3,107	—	—	—	—	—	—	1,441
June	269	400	968	916	2,553	—	—	—	—	—	—	1,224
July	228	310	739	695	1,972	691	2,663	220	2,883	2,819	2,927	934
Aug.	181	192	561	818	1,752	—	—	—	—	—	—	817
Sept.	290	386	521	2,083	3,280	—	—	—	—	—	—	1,714
Oct.	215	217	753	4,252	5,437	—	—	—	—	—	—	3,385
Nov.	634	810	1,097	4,955	7,496	—	—	—	—	—	—	4,465
Dec.	809	906	1,385	4,658	7,758	—	—	—	—	—	—	4,914
1925, Jan.	1,011	945	1,503	3,898	7,357	1,004	8,361	—	—	—	—	4,746
Feb.	1,048	910	1,613	3,124	6,695	—	—	—	—	—	—	4,373
Mar.	984	934	1,708	2,263	5,889	—	—	—	—	—	—	3,794
April	891	836	1,588	1,676	4,991	—	—	—	—	—	—	2,945
May	722	654	1,413	1,144	3,933	—	—	—	—	—	—	2,255
June	577	548	1,187	774	3,086	—	—	—	—	—	—	1,730
July	401	373	915	516	2,205	1,046	3,251	300	3,551	2,880	—	1,140
Aug.	264	292	707	1,040	2,303	—	—	—	—	—	—	1,117
Sept.	273	471	883	3,136	4,763	—	—	—	—	—	—	2,387
Oct.	458	822	1,246	4,509	7,035	—	—	—	—	—	—	4,157

[1] Excluding Linters.

TABLE II.—WORLD'S CARRY-OVER OF EGYPTIAN COTTON.

Kantars (000's): bales converted at 7·5 kantars (Europe) and 5 kantars (U.S.A.)

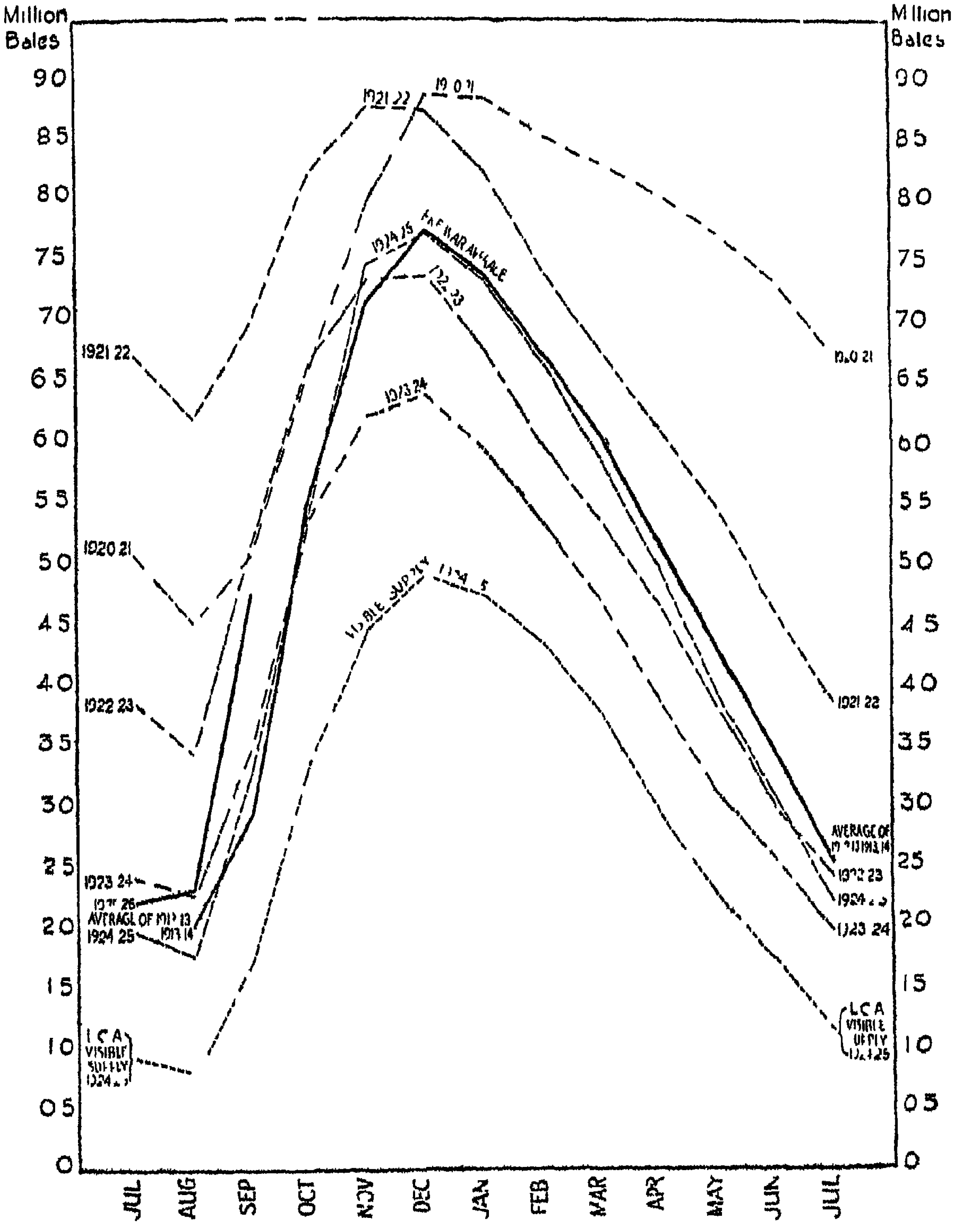
End of—	*Stock and Afloat.*		*U.S.A.*		*Alexandria.*	*Monthly Total.*	*Federation. Half-Yearly.*	*Half-Yearly Total.*
	U.K.	*Cont.*	*Mills.*	*Warehouses.*				
1912, Aug. ..	302	30	424*	—	350	1,106	1,387	2,493
1913, Feb. ..	652	122	418*	—	2,176	3,368	2,070	5,438
Aug. ..	418	31	354	13	491	1,307	1,485	2,792
1914, Feb. ..	765	98	185	24	2,606	3,678	2,130	5,808
Aug. ..	467	10	259	26	766	1,528	—	—
1915, Jan. ..	921	127	227	43	2,328	3,646	—	—
July ..	758	71	484	126	1,074	2,513	—	—
1916, Jan. ..	1,347	93	336	91	1,377	3,244	—	—
July ..	351	50	617	296	104	1,418	—	—
1917, Jan. ..	1,270	98	357	146	1,225	3,096	—	—
July ..	431	27	376	213	589	1,636	—	—
1918, Jan. ..	1,001	25	136	87	2,651	3,900	—	—
July ..	541	185	180	157	1,727	2,790	—	—
1919, Jan. ..	607	80	207	86	2,896	3,876	—	—
July ..	526	170	185	79	2,060	3,020	—	—
1920, Jan. ..	1,291	282	277	165	1,532	3,547	1,852	5,399
July ..	466	79	587	514	601	2,247	1,365	3,612
1921, Jan. ..	446	151	415	336	1,606	2,954	1,035	3,989
July ..	688	158	345	296	1,992	3,479	1,005	4,484
1922, Jan. ..	1,043	204	317	322	2,511	4,397	1,087	5,484
July ..	835	148	314	267	1,669	3,233	1,252	4,485
1923, Jan. ..	1,354	272	315	285	2,380	4,606	1,177	5,783
July ..	899	129	432	257	1,096	2,813	1,200	4,013
Aug. ..	668	112	379	221	803	2,183	—	—
Sept. ..	607	143	331	185	948	2,214	—	—
Oct. ..	592	240	268	171	1,527	2,798	—	—
Nov. ..	923	322	244	131	2,190	3,810	—	—
Dec. ..	1,155	307	227	134	2,148	3,971	—	—
1924, Jan. ..	1,155	322	324	125	1,841	3,767	1,320	5,087
Feb. ..	1,050	255	351	105	1,690	3,451	—	—
Mar. ..	877	165	350	89	1,506	2,987	—	—
April ..	772	180	334	94	1,239	2,619	—	—
May ..	765	180	326	93	892	2,256	—	—
June ..	713	172	295	99	634	1,913	—	—
July ..	517	128	259	63	384	1,351	1,155	2,506
Aug. ..	450	68	224	40	286	1,077	—	—
Sept. ..	435	120	183	35	628	1,401	—	—
Oct. ..	518	217	137	32	1,453	2,357	—	—
Nov. ..	608	135	125	34	1,961	2,863	—	—
Dec. ..	840	285	175	37	1,964	3,301	—	—
1925, Jan. ..	683	195	260	54	1,892	3,084	1,215	4,299
Feb. ..	758	277	319	56	1,614	3,024	—	—
Mar. ..	668	127	358	107	1,368	2,628	—	—
April ..	653	135	328	129	1,091	2,336	—	—
May ..	630	120	321	102	814	1,987	—	—
June ..	533	97	295	77	647	1,649	—	—
July ..	443	75	253	57	411	1,239	1,103	2,342
Aug. ..	383	60	209	39	295	986	—	—
Sept. ..	345	98	180	42	660	1,325	—	—
Oct. ..	473	187	130	30	1,576	2,396		

* Total foreign—details not given.

with regard to American and Egyptian. By compiling the L.C.A. figures for the last week of each month for the United Kingdom and Continent, and adding to these the Census Bureau's monthly figures of Visible and Invisible Stocks (i.e., warehouse and mill stocks) in U.S.A., it is possible to get a monthly statement which covers probably about 60 to 70 per cent. of the total world stocks of American cotton, and a similar statement for Egyptian can be obtained by using the Alexandria figures of the A.G.P.A. These may be called the world's monthly carry-overs. Then, by adding at the end of each half-year the Federation Mill Stocks for countries other than the U.S.A., it is possible to get very nearly a complete statement of the figures at these dates, though it is only at the end of the season, when the Census Bureau's figure for "elsewhere" in U.S.A. becomes available, that the American figure is most nearly complete. In the preceding pages we give these two tables. In the case of the American carry-over we have added for comparison Hester's figures and those of the Census Bureau at the end of the season so far as these are available. We also give the L.C.A. figures of the Visible Supply, and it will be noted that these on the whole tally fairly well with our monthly totals, deducting therefrom the American Mill Stocks.

The main point of interest to be derived from these carry-over tables, especially the American, is that there is a more or less normal curve followed by the monthly figures. This is brought out in the annexed diagram of the American carry-over, which gives the average of two pre-war years (1912-13 and 1913-14), and the monthly history of every season since 1920-21, along with the Visible Supply for 1924-25. 1920-21 began with a fairly high carry-over (a legacy from 1918-19), but this was quickly reduced by the 1921-22 season, during the latter half of which consumption made a most unexpected recovery; and for the next two years the carry-over was reduced each season, until at the end of 1923-24 the total was reduced to the smallest figure in our records. It was at first thought that the comparatively ample crop of 1924 would add very largely to the carry-over, but, owing again to the remarkable recovery of consumption, this hope was not fulfilled, and the carry-over at the end of the season was little more than half a million bales above that of its predecessor. The current season therefore began with nothing more than a normal carry-over. It has, of course, shown a rapid rise so far, owing to the earliness of the crop, but it will be interesting to watch it through the critical point of the season. This, as will be seen from the diagram, is either at the end of November or December. Normally, the carry-over continues to rise till the end of December, and then falls more

WORLD'S MONTHLY CARRYOVER OF AMERICAN COTTON



or less rapidly. In 1921 the figure at the end of December was actually lower than the previous month, which proved the forerunner of the biggest drop on record in the carry-over in the course of a single season.

Space prevents the production in this issue of a corresponding diagram of the Egyptian monthly carry-over, but it may be possible to do so in a future issue. As will be seen from Table II., however, the normal course of the carry-over throughout the season is much less definitely marked, the peak point varying between December and February, and in one case (1920-21) there was actually a fresh rise which carried the figure to a new peak at the end of July. At the end of season 1923-24 the monthly carry-over touched the lowest point in our records up till then, but this was beaten again at the end of last season, with the result that the current season started with the lowest figure on record, but is going up rapidly like its predecessor.

NOTES ON CURRENT LITERATURE

COTTON IN INDIA.

1. CAMBODIA COTTON. (*Digest of operations of the Dept. Agric. Madras in June, 1925.*) On p. 10 we read: "The variety of cotton commonly grown in Vizagapatam district is Tollapathi (*G. herbaceum*) . . . usually sown in the early season in dry land mixed with either red gram or gingelly. The crop is only grown on small areas, and it is not of much commercial importance. Cambodia cotton has been tried on the station for a number of years, and it has been sown both in the early season and just before the beginning of the north-east monsoon period. In some cases up to 1,200 lbs. kapas per acre has been harvested, but in most years the yields have been poor. The variety has proved to be very adversely affected by abnormal seasonal variations, and an excess of soil water produces a check in growth, from which it does not readily recover."

2. The first Government cotton forecast for India, dated Calcutta, August 20, 1925, gives an increase of 27 per cent. in the acreage (*Internat. Cott. Bull.*, iv., October, 1925, p. 90.)

And *cf.* abstr. 133, 142, 150.

COTTON IN THE EMPIRE (EXCLUDING INDIA).

3. The following Reports have recently been received:

Nigeria. "Annual Report of the Department of Agriculture," 1924.

Southern Rhodesia. "Meteorological Report for year ended September 30," 1924.

Uganda. "Annual Report of the Department of Agriculture," 1924.

Trinidad and Tobago. Report for 1924.

4. COTTON PRODUCTION IN THE BRITISH EMPIRE. (*Int. Cotton Bull.*, 1925, 3, 605-609. Abstr. in *Summ. Curr. Lit.*, vol. v., 17, E. 86, October, 1925.)

5. AMERICAN COTTON TYPES IN THE BRITISH EMPIRE. By P. H. Lamb, Dep. Dir. Agr. Nigeria. (*Manch. Guard. Comm.*, August 20, 1925, p. 42.) The history of the gradual diminution of American supplies from various causes is first dealt with, and then the pioneering work of the British Cotton Growing Association, which is now beginning to show such important results—results which are indicated by approximate figures of Empire production from 1918 onwards. The fact that the Empire cotton is of better grade and usually of longer staple is especially emphasized. Probable future progress is then considered under four heads. In tropical Africa it is pointed out that the cotton is produced by hand labour, and that the climate of Uganda, with its well-distributed rainfall, has enabled that country, by providing it with ample food, to go ahead of the rest. The greatest need at present is improved transport facilities, and the Corporation's trials of half-track lorries are specially mentioned. The question of the improvement of cotton (especially in the direction of greater ginning percentage, which is so important when the methods of transport are primitive) is then gone into. The economic advantages of the small plot system of cultivation in tropical Africa are pointed out, whilst in South Africa European cultivation on large areas with native labour shows many advantages. The third area, Australia, is trying to grow cotton with white labour only, a fact which very definitely limits the possible output, and calls for a product of high quality. Finally, India, perhaps the most promising field of all, is considered.

6. EUROPE: CYPRUS. (*Annual Rep. of Dept. Agric.*, 1924, p. 5.) Unfortunately, owing to the ravages of the Cotton Boll Worms (*Gelechia gossypiella* and *Earias insulana*), the cotton crop was a poor one. There has been a marked increase in these pests, and drastic measures to combat them have of necessity to be taken. Towards the end of the year an order was issued under the Diseases of Plants Prevention Law, 1893, directing that within any area declared to be infected with the disease all cotton plants should be pulled up and burnt or otherwise destroyed before a certain date, so as to prevent further production of the plants. Although, as was to be expected, the measure was not altogether popular, still the farmers are now aware that unless very severe measures are taken they will ultimately be the losers.

Approximately 36,400 cwt. of cotton was produced in 1924, as compared with 23,900 cwt. in 1923.

7. ASIA: CEYLON. *Cotton Cultivation.* (*Times of Ceylon*, and *Commerce*, Calcutta.) A total of 2,000 acres round Hambantota has been cultivated by small growers this year, but of these 400 acres have been damaged by stray cattle and produced no crop. At the Government Experiment Station, Hambantota, the best results have been obtained from Durango and Watts Long Staple, and if the length of staple is maintained, these will be suitable for the European market.

8. 'IRAQ. Advices from 'Iraq state that cotton remains very free from all disease. The Spotted Boll Worm (*Earias insulana*) has been reported from various plantations, but nowhere is the attack severe. At the Experimental Farm the intensity of attack on the crops is certainly less than one-tenth of what it was at this time last year. In irrigated tracts, however, much cotton is being forced into premature opening by water-shortage, and a dull, weak-stapled cotton is being picked. Pickings become general in early August, and the British Cotton Growing Association have commenced buying at Rs. 500 per ton for first-class cotton. The present market price of raw cotton does not justify this high price, and unless the Liverpool market hardens, which is not considered likely at present, the price will probably have to be reduced.

9. AFRICA: KENYA. (*Annual Rep. of Dept. Agric.*, 1924, p. 22.) Cotton has been grown fairly extensively in some districts: the acreage planted during the year exceeded 30,000. The crop was not well favoured by weather.

10. NIGERIA. *Cotton Production.* (*Manchester Guardian*, May 23, 1925. Abstr. from *Summ. of Curr. Lit.*, vol. v., 14, 1925, E. 75.) Private advices estimate the purchases by the B.C.G.A. of Northern Nigerian cotton this year to be 24,000 bales, an increase of 33 per cent. on last year's total. Part of the crop is also consumed locally, and probably 4,000 bales are exported into the adjacent French territories each year. Fire is reported to have destroyed 2,000 bales at Zaria.

11. From the *Annual Report on the Agric. Dept. of Nigeria* for the year 1924, recently received from the Director of Agriculture, we extract the following information:

Northern Belt.—Two slightly improved strains of American cotton have been tested as to yielding powers and found satisfactory, and are now being multiplied for distribution. Further selection work is being carried out, and gives promise of good results.

For the first time, this year, the prices to be paid for the different grades of seed cotton were not fixed at the beginning of the buying season. In spite of a considerable fall in the prices offered towards the close of the 1924 buying season, the quantity of cotton sold for export showed that the discontinuance of the fixed price had had no serious effect.

Assistance from Empire Cotton Growing Corporation.—It is reported that the Corporation have approved a scheme whereby they will establish and manage for the Government a number of small seed farms. The Corporation are also sending, for trial under tropical conditions in Northern Nigeria, specimens of two different types of "caterpillar track lorries" which they have been testing in England. It is hoped that such "track vehicles" will prove the solution of most of the road transport difficulties in tropical colonies. (A Report on these vehicles is shortly to be issued by the Corporation.—Ed. *E.C.G.R.*)

Middle Belt.—The crop has been, relatively, a small one.

Southern Belt.—The experimental work at Moor Plantation has been continued, and, in addition, five trial plots of 1 acre each of American cotton, and the same number of plots of native cotton, were grown on the Oyo-Ogbomosho road. A similar series of plots was planted on the main road near Ilugun. The results obtained from these plots and from the work last year seem to establish the fact that where cotton is grown unmixed with other crops the American variety gives a heavier yield of more valuable produce than the native.

12. NYASALAND. (*Rep. of Dept. of Agric.*, 1924.) The amount of cotton lint produced by European planters was 771 tons on 26,120 acres, a yield which leaves room for improvement. Boll worm was less marked than previously, but much damage was done by both rot and cotton stainers. The amount of seed cotton produced by natives was nearly double that grown in 1923.

13. EAST AND CENTRAL AFRICA. (*Manch. Guard. Comm.*, Wembley, 1925, August 13, 1925, p. 25.) In the article upon Nyasaland, by Colonel G. M. Sorley, the adoption of the new methods of cultivation, designed by Mr. H. C. Sampson, the Corporation's expert, is mentioned, with the resulting improvement in yield and reduction of expense. Other rotation crops than maize and millet are to be tried, and productivity is being increased by the introduction of machinery. Rotation is considered the best means of combating the boll worm.

14. "Our Nyasaland Letter" in *East Africa* of August 6 urges Nyasaland to devote more attention to cotton growing, and states that there is a large area of suitable land in the Lower Shiré district.

15. RHODESIA. *Notes on Fertilizing and Soil Treatment.* By T. J. Mossop. (*Rhod. Agric. Journ.*, xxii., 4, p. 457.)

16. *Selling Rhodesian Cotton in Liverpool.* By W. C. Aman. (*Rhod. Agric. Journ.*, xxii., 4, p. 466.) Strong, hard cotton will find a readier sale on the Liverpool market and fetch a better price than cotton of the same grade if weak and soft. Lancashire spinners will probably not be able to spin yarn out of Rhodesia cotton as it was produced last year without mixing it with cotton of a stronger character.

17. *Cotton Seed Supply.* By G. S. Cameron, E.C.G.C. Cotton Specialist, South Rhodesia. (*Rhod. Agr. Journ.*, xxii., September, 1925, p. 660.) Mr. Cameron thinks that the cotton industry has grown somewhat too rapidly, and that the supply of good seed will be a serious problem. He advises farmers to be careful in buying their seed, and to obtain it from crops that have yielded 500 lbs. of seed cotton to the acre. This might perhaps be best arranged through the district associations.

18. *Climatic Conditions and Cotton Growing in Southern Rhodesia.* By C. L. Robertson, B.Sc., Hydrographic Engineer. (*Rhod. Agr. Journ.*, xxii., October, 1925, p. 745.) It is shown how greatly the conditions differ from those in the cotton belt of North America, and a map is given showing roughly the distribution of the conditions, the shaded part being that which apparently will suit cotton without irrigation.

19. *The Effects of Land Settlement on Mining and Cotton Growing in Rhodesia.* By J. G. McDonald and John Hynd. (*Afr. Cott. Journ.*, i., July 8, 1925, p. 18.)

20. *Progress in Bindura District: Opening of the First Co-operative Ginnery.* (*Afr. Cott. Journ.*, i., July 8, 1925, p. 12.)

21. South Africa. *South Africa's Grounds for Optimism.* By J. S. Smit, High Commissioner for the Union of South Africa. (*Manch. Guard. Comm.*, Wembley, 1925, August 13, 1925, p. 9.) The Corporation's valuable advice and assistance are specially referred to, and it is pointed out that a newcomer with adequate capital and after practical training in the country has as good a chance with cotton in South Africa as anywhere.

22. *Cotton in South Africa.* (*Official Year Book of the Union of S. Afr.*, 1924.) The references to cotton relate mainly to 1923, and deal with chemical investigations, cultivation, exports, prices, etc.

23. *Cotton Growing in the Gamtoos Valley.* (*Afr. Cott. Journ.*, vol. i., **15**, 1925, p. 4.) For the season 1924-25 the entire crop was graded "Strict Good Middling," and fetched 14½d. and 14·9d. per lb. of lint in Durban.

24. *Activities of the Kynoch Ginnery.* (*S. Afr. Cott. Growers' Journ.*, vol. ii., **1**, p. 11.)

25. *The 1925 Cotton Crop of the Union: A Review of the General Aspect.* (*S. Afr. Cott. Growers' Journ.*, vol. ii., **1**, p. 19.)

26. *The Cotton Planter and His Problems.* (*S. Afric. Cotton Growers' Journal*, ii., **3**, 1925, p. 27.)

27. *Irrigation in Relation to Unemployment.* (*Sun and Agric. Journ. of S.A.*, July, 1925, p. 665.) An interview with Mr. R. A. Rouillard, Managing Director, Candover Estates, Natal, giving an outline of what he hopes may be accomplished by his scheme of land development under irrigation.

28. *Concerning Cotton.* By E. J. O'Connor. (*S. Afric. Cotton Growers' Journal*, ii., **2**, 1925, p. 31.) A consideration of soil conditions, with special reference to Natal.

29. *Rustenburg Cotton.* (*African Industries*, vol. xi., **10**, p. 82.)

30. *Cotton Growing in Griqualand West.* By F. W. Jameson. (*Afr. Cott. Journal*, i., July 8, 1925, p. 35.)

31. *The Locust Problem in South Africa.* By R. H. Williams, Officer Commanding the Locust Administration, Union Dept. Agr. (*Sun and Agr. Journ. of S.A.*, vol. xvi., **129**, Sept., 1925, p. 852.)

32. Sudan. (Extracted from the *Ann. Rep. Centr. Econ. Board, Sudan Govt.*, 1924-25.) Water from the new dam at Sennar on the Blue Nile was available for the first time this summer (1925); 100,000 acres are to be cultivated annually with cotton, and it is expected to have 80,000 acres ready for cotton in the first season. The inauguration of the scheme will vest the Sudan with great potentialities as a cotton-producing country.

The extension of the railway to Kassala has been under regular working from November, 1924. The production of cotton at Kassala was estimated to be 7,500 bales of 400 lbs. this season. The cotton is of the long-stapled Egyptian type.

Encouraging results are announced of the campaign for increasing the growth of rain-grown (American) cotton in the Central and Southern Sudan. It is largely owing to increase in this kind of cotton that the total exports rose from 28,056 bales of 400 lbs in 1923 to 46,074 bales in 1924. To deal with rain-grown cotton a new ginnery is to be erected at Makwar, while another is being built at Atbara to deal with American and other cotton grown under pump irrigation north of Khartoum. Both factories are being built by the Government, who will, for the present, control all ginning in the country with a view to maintaining purity of the type of cotton, and to preventing the spread of diseases and pests.

The following tables show the areas under cotton in 1922, 1923, and 1924, and the quantities of lint (in feddans) exported in those years:

	1922.	1923.	1924.
Cotton grown on rain land	3,304	6,147	13,524
Cotton grown under artificial irrigation ..	24,058	25,064	40,037
Cotton grown on flood land	56,011	30,377	58,105
Total	81,273	61,588	111,666

1922	24,240
1923	28,056
1924	46,074

As compared with 1923, there was an increase of 18,018 in the number of bales exported, equivalent to 64 per cent.

33. *Cotton Growing in the Sudan.* By Sir Geoffrey Archer, Governor-General. (*Manch. Guard. Comm.*, Wembley, 1925, August 13, 1925, p. 14.) A general discussion, pointing out the great increase of recent years, now to be much greater with the opening of the Gezira irrigation scheme.

34. *Cotton Growing in Uganda and the Sudan.* By Sir Geoffrey Archer. *East Afr.*, 2, October 15, 1925, p. 71.)

35. *Cotton Production in Anglo-Egyptian Sudan.* (*Int. Cotton Bull.*, 1925, 3, 509. Abstr. in *Summ. Curr. Lit.*, vol. v., 17, E. 86, October, 1925.)

36. *Sudan, Cotton Prospects.* By Arthur Ransome. (*Manchester Guardian*, May 15, 1925.)

37. *Cotton in the Sudan.* (*Manch. Guard. Comm.*, Wembley, 1925, August 13, 1925, p. 15.) Mainly a description, with map, of the Gezira irrigation scheme.

38. *Gezira Irrigation Works.* (*Engineer*, 1925, 140, 211. Abstr. *Summ. of Curr. Lit.*, vol. v., 16, 1925, E. 84.) The technical details of the Gezira schemes are provided by the consulting engineers in charge. A ground plan of the canalization and controls for the first 300,000 feddans is shown, and photographs to illustrate details of construction are reproduced.

39. TANGANYIKA. *Cotton in Tanganyika Territory.* (*Rep. on Administration of Tanganyika Territory*, 1924, p. 47, H.M. Sta. Office.) The Government policy is to encourage the production of cotton of the best quality without endangering the cultivation of native foodstuffs. Administrative and Agricultural Officers are aware of the need for an economic value of cotton, as well as of its value to the natives as a cash crop. Instructions have been issued on protection of cotton against insect pests, and natives have been impressed with the importance of strict

49. *Durango Cotton: Coming Season's Planting in Queensland.* (*Queensl. Agr. Journ.*, xxiv., 2, August, 1925, p. 201.) Questioned on the suggestion that only Durango cotton seed should be issued for planting during the coming season, the Minister for Agriculture (Hon. W. Forgan Smith) has announced that it is the policy of the Government to encourage the planting of better quality cotton, and for this reason he is anxious to see as large an area of Durango planted in the coming season as possible. This variety has given most promising results over large sections of the State, and in those few instances where it is reported to have yielded poorly the cause was apparently due to unfavourable weather conditions, rather than to any inherent fault in the seed. Durango is the only pure variety of which the Department has any large quantity of seed yet available, and in order to safeguard the purity of the Durango seed, the Department is arranging for pure seed areas grown by communities of farmers who have expressed their desire to co-operate.

50. WEST INDIES: BARBADOS. (*Rept. of Dept. Agric.*, 1923-24.) On p. 3 an account is given of the favourable reception of Barbados cotton in Liverpool, and of the discovery of the pink boll worm in this island, one of the last places to remain free of this pest.

51. ST. KITTS-NEVIS. (*Report on the Agric. Dept.*, 1923-24.) There was an increase in the area planted in cotton in the Presidency during the year 1923-24, but the increase was chiefly in Nevis. The total estimated area planted was as follows:

	Acres.	
St. Kitts	1,000	
Nevis	2,500	
Anguilla	500	(estimated)
Total	4,000	

Experimental work with cotton is described on p. 30. Pink boll worm did very little damage to the first picking of cotton, but later in the season was present in large numbers, and seriously affected the later planted cotton. The most effectual remedy for this pest—in fact, the only practical one—is rigid cleaning up and burning of all old cotton plants, inspection of the fields before new crops are planted, cleaning-up of all cotton storehouses and ginneries by a given time, all under the supervision of a Cotton Inspector.

52. MONTSERRAT. (*Rep. on the Agric. Dept.*, 1922-23 *and* 1923-24.) 1,324 lbs. of selected cotton seed were distributed in 1923 for the planting of special seed fields. In 1924, 2,177 lbs. were issued for the same purpose. On pp. 4-22 the results of the Department's experimental work are described. These are chiefly of the nature of interim reports dealing specially with the breeding work that is going on, and with the pink boll worm.

The Cotton Industry is dealt with on p. 34, and it is mentioned that the spread of dry farming methods is having a good influence on the yield, which averaged 199 lbs. of lint per acre in 1923-24.

And *cf.* abstr. 103, 111, 114, 118, 124, 128, 151-2, 160, 166-7.

COTTON IN THE UNITED STATES.

53. EXTRACT OF REPORT ON THE 1925 JOURNEY THROUGH THE U.S.A. By Arno S. Pearse, Gen. Sec. Internat. Cott. Fed. (*Internat. Cott. Bull.*, iv., October, 1925, p. 2.) Among the subjects of interest dealt with are Co-operative Cotton Farmers' Associations, Standardization of Bales, Internal Damp, Snapping of Cotton ("a

process of gathering the whole capsules, or bolls, and putting them, often with stalks and leaves, through a boll-breaker and cleaner before ginning." It appears to be a procedure that is on the increase, on account of cheapness and quickness, even though it may tend to lower the grade. Half-and-half variety (short staple, $\frac{5}{8}$-$\frac{7}{8}$, but ginning percentage as high as 48), Cotton-growing in New Territory (nearly 450,000 bales are raised in places where there was no cotton ten years ago - a suggestive comparison with tropical Africa), Boll-weevils, and other topics.

54. Cost of Producing Cotton in Fifteen Selected Areas. By L. E. Long and C. R. Swinson. (*Internat. Cott. Bull.*, iv., October, 1925, p. 36.) The various factors (labour--for each of the operations required—mule labour, fertilizers, etc.) are carefully analyzed for a great number of farms, and summarized.

55. Cost of Producing Field Crops, 1923. (*U.S. Dept. Agric., Circular* 340, 1925.)

56. Field and Crop Labour on Georgia Farms. (*U.S. Dept. Agric., Bull.* 1292, 1925.) A detailed analysis of the distribution and cost of labour for various crops, including cotton.

57. Does Cotton Growing Pay? American Raw Cotton Costs and Selling Prices. By W. Whittam. (*Text. Recorder*, xliii., **510**, p. 40.) A recent publication of the U.S. Dept. of Agric. dealing with the cost of cotton production in 1924 on 1,471 farms shows that the average was 18 cents per lb. of lint, the cost, of course, being greater with low and less with high production.

58. U.S.A. (Mississippi Delta) Long Staple Cotton. By W. M. Garrard. (*Int. Cotton Bull.*, 1923, **3**, 419-420; from *Commerce and Finance*, January 14, 1925. Abstr. in *Summ. Curr. Lit.*, vol. v., **17**, E. 92, October, 1925.) A table prepared at the Delta Experimental Station shows the relation between lint length, yield, and the price necessary for profitable cultivation of each length. The prices are arranged to yield a return of 245 dollars per acre for each type. The average yield of lint from ten years' experiments at Stoneville, 1911-20, of $\frac{7}{8}$ to 1 inch cotton was 1,000 lbs.; $1\frac{1}{8}$ inches yielded 897 lbs.; $1\frac{3}{16}$ inches, 743 lbs.; $1\frac{1}{4}$ inches, 688 lbs.; and $1\frac{3}{8}$ inches, 475 lbs. The prices required to make the money value the same for each staple were $\frac{7}{8}$ to 1 inch, 24·50 cents; $1\frac{1}{8}$ inches, 27·31 cents; $1\frac{3}{16}$ inches, 32·11 cents; $1\frac{1}{4}$ inches, 35·61 cents; $1\frac{3}{8}$ inches, 51·58 cents. At the time of enquiry the growers of 1, $1\frac{3}{16}$, and $1\frac{1}{4}$ inches were selling on about an even basis; and the grower of $1\frac{1}{8}$ inches staple had an indicated advantage of $2\frac{1}{2}$ cents. The premium on long staple, however, has not been sufficiently high, and the growing of this cotton in the Delta is diminishing. Cotton of $1\frac{1}{8}$ inches staple is easier to grow, earlier in maturity, less pest ridden, and always in demand.

59. American Cotton: Annual Review. (*Manch. Guard. Comm.*, August 20, 1925.) Several interesting articles are included, such as one by V. H. Schoffelmayer on "The Westward and North-Westward Shift of the Cotton Belt in Texas"; by C. E. Collins on "Labour Supply"; by D. R. Coker on "The Tendency to Cultivate Cotton of Longer Staple," and on many other aspects of the industry, especially an article by P. H. Lamb on "American Cotton Types in the Empire" (p. 56).

60. American Cotton Belt: Diversified Farming. (*Text. Rec.*, 1925, **43**, No. 507, p. 48.) Attempts to persuade farmers in the cotton belt to diversify their crops have as yet had but little effect, and the cotton belt, in its devotion to one crop, somewhat resembles the tea districts of Ceylon or the rubber areas in Malaya.

61. Wasteful Handling of American Cotton. By C. L. Stealey. (*Internat Cott. Bull.*, iv., October, 1925, p. 48.)

62. Supply and Consumption of American Cotton: An Estimate of the Position. By John A. Todd. (*Internat. Cott. Bull.*, iv., October, 1925, p. 78.)

63. Experiments with Field Crops in Georgia, 1924. (*Georgia Sta. Rpt.*, 1924, pp. 64-66, 67, 68-70, 85, figs. 8. Abstr. in *Exp. Sta. Rec.*, vol. **53**, No. 3, 1925.

64. Field Crops Work at the South Mississippi Substation, 1923 and 1924. By E. B. Ferris and R. C. Price. (*Mississippi Sta. Bul.*, 225 [1924], pp. 4-9. Abstr. in *Exp. Sta. Rec.*, vol. **53**, No. 3, 1925.)

65. Cotton Experiments, 1924. By J. F. O'Kelly and R. Cowart. (*Mississippi Sta. Bul.* 226 [1924], pp. 3-12, fig. 1. Abstr. in *Exp. Sta. Rec.*, vol. **53**, No. 3, 1925.)

66. Report on South-East Missouri Cotton Experiment Fields, 1924. By B. M. King. (*Missouri Sta. Circ.* 132 [1925], p. 4. Abstr. in *Exp. Sta. Rec.*, vol. **53**, No 3, 1925.)

67. Cotton Investigations in South Carolina. (*S. Carolina Sta. Rpt.*, 1924. Abstr. from *Exp. Sta. Rec.*, vol. **52**, 6, 1925, p. 531.) These pages report experiments continuing and supplementing previous work (*E.S.R.*, 50, p. 638; 51, p. 231). Although closely spaced cotton was little earlier than wide spaced during a very wet season at Florence, the earliest and best yields came from spacing as close as 9 or 12 inches. At Clemson the closely spaced cotton continued to give the highest yield and the earliest crop. The results obtained indicate that the earliest crop and the highest yields are apt to be obtained from a spacing giving from 15,000 to 20,000 plants per acre, at which rate an average of five to six mature bolls per stalk will yield a bale of cotton per acre. Acid delinted seed again excelled in the seed treatment tests. Plats chopped as soon as a stand was obtained gave the best yields.

68. Cotton Growing on the South-Western Projects. (*New Reclam. Era* [*U.S.*], 16 [1925], No. 1, pp. 7-9, 3 figs. Abstr. in *Exp. Sta. Rec.*, vol. **53**, No. 2, 1925, p. 136.) The methods in general use on the Salt River, Yuma, Carlsbad, and Rio Grande irrigation projects are outlined.

69. Pima Cotton: Certification. (*Text. World*, 1925, **68**, 1472. Abstr. in *Summ. Curr. Lit.*, vol. v., **17**, E. 93, October, 1925.) Owing to the growth last year of short-stapled cottons in the Salt River Valley, the area in which Pima cotton was previously grown, much of the seed used for planting this year was very mixed, and short-stapled and hybrid plants appeared in the Pima cotton fields. Many farmers have rogued their fields, removing all short staple and hybrid plants. Rogued fields are examined by the County Agricultural Agent, and a certificate is issued to the farmer if the result is satisfactory. A distinguishing mark or tag will be placed on each bale of certified Pima cotton.

And *cf.* abstr. 104-7, 115-17, 153.

COTTON IN EGYPT.

70. Notes on the Importance of Using Good Cotton Seed (Taqawi), and a General Method of Obtaining Such Seed. By T. E. Bayne-Jardine. (*Agric. Journ., Egypt*, New Ann. Series, 1923. *Trop. Agriculturist*, lxv., **1**, p. 33.)

71. Review of the 1924-25 Egyptian Cotton Season, and Prospects for 1925-26. By J. G. Joannides and Co. (*Internat. Cott. Bull.*, iv., October, 1925, p. 82.)

72. REPORT ON THE ECONOMIC AND FINANCIAL SITUATION IN EGYPT. June, 1925. By E. H. Mulock, Commercial Secretary, Cairo. H.M. Stat. Off., 2s. On p 7 it is stated that "it is chiefly cotton which is responsible for the increased measure of prosperity of Egypt indicated . . . accounted for practically entirely by a rise of over £E7,000,000 in the value of cotton exported during . . . 1924."

73. COTTON CULTIVATION IN EGYPT. (*Int. Cotton Bull.*, 1925, **3**, 441-446. Abstr. in *Summ. Curr. Lit.*, vol. v., **17**, E. 86, October, 1925.) The life of a variety in Egypt is said to average about twenty years. The suggestion of "one district, one variety," is under consideration as a rule for Egyptian cultivation.

74. FUADY EGYPTIAN COTTON (*Text. Merc.*, 1925, **73**, 300. Abstr in *Summ. Curr. Lit.*, vol. v., **17**, E. 87, October, 1925.) A new variety bred by Parachimona has been designated "Fuady" after King Fuad.

And *cf.* abstr. 110, 122.

COTTON IN FOREIGN COUNTRIES.

75. We have received from the Association Cotonnière Coloniale *Bulletins* Nos 71 and 72.

76. WILL ARGENTINA CONTINUE TO GROW COTTON? By E. L. Tutt. (*Internat. Cott. Bull.*, iv., October, 1925, p. 95.) Showing that the limiting factor will be population.

77. ARGENTINA CULTIVATION. (*Faserforschung*, 1925, **4**, 195-197. [Hans Seckt.] Abstr. in *Summ. Curr. Lit.*, vol. v., **17**, E. 87, October, 1925.)

78. ARGENTINA PRODUCTION, 1925. (*Int. Cotton. Bull.*, 1925, **3**, 599. Abstr. in *Summ. Curr. Lit.*, vol. v., **17**, E. 87, October, 1925.) The new crop is estimated at 74,700 bales of 478 lbs, an increase of only 5,000, although the acreage sown was 259,000 as compared with 155,000 last year. Locust and excessive drought are the main causes of the poor yield.

79. COTTON PRODUCTION IN ARMENIA. (*Int. Cotton. Bull.*, 1925, **3**, 600-601. Abstr. in *Summ. Curr. Lit.*, vol. v., **17**, E. 88, October, 1925.)

80. COTTON CULTIVATION IN BRAZIL. (*Int. Cotton Bull.*, 1925, **3**, 603-605. Abstr. in *Summ. Curr. Lit.*, vol. v., **17**, E. 88, October, 1925.)

81. BRAZIL COTTON CULTIVATION. (*Text. Merc.*, 1925, **73**, 221. Abstr. from *Summ. Curr. Lit.*, vol. v., **16**, 1925, E. 79.) The 1924-25 Brazilian cotton crop is officially estimated at 131,118 tons, or 582,746 bales of 500 lbs This is an increase over the previous crop of 6,243 tons.

82. BRAZIL (MINAS GERAES), COTTON PRODUCTION IN. (*Int. Cott. Bull.*, 1925, **3**, p. 384.)

83. THE BRAZILIAN COTTON PRODUCTION, 1924-25. By A. Grieder. (*Internat. Cott. Bull.*, iv., October, 1925, p. 98.) So large an amount of cotton is used in Brazil (about 450,000 bales of 500 lbs.) that the export is still small. The best average yield of lint per acre is in São Paulo (227 lbs.), which produced 155,000 bales in 1924 25.

84. CHINA, COTTON MILL STATISTICS, 1923. (*Int. Cott. Bull.*, 1925, **3**, 588.) A table is given showing the location of mills, capital employed, the number of spindles or looms, power, and labour supply and cotton consumed, for the year 1923. A summary indicating ownership is as follows:

	Chinese.	*British.*	*Japanese.*
Number of mills	73	5	41
Spindles	2,112,154	250,516	3,581,214
Looms	13,680	2,863	5,925

85. Cotton Cultivation in China. (*Text. Merc.*, 1925, **72**, 560. Abstr. in *Journ. Text. Inst.*, xvi., **8**, August, 1925, p. A248.)

86. Cotton Growing in Shansi (China), Laguna (Mexico), New Caledonia, Paraguay, Peru, Etc. (*Internat. Cott. Bull.*, iv., October, 1925, pp. 101, 104, 109, 110.)

87. Cotton Production in China. (*Int. Cotton Bull.*, 1925, **3**, 610. Abstr. in *Summ. Curr. Lit.*, vol. v., **17**, E. 89, October, 1925.)

88. Cotton Production in Colombia. (*Ditto*, 610. Abstr. in *Ditto*, E. 89.)

89. Cotton Cultivation in Costa Rica. (*Ditto*, 610. Abstr. in *Ditto*, E. 89.)

90. Cotton Production in French Colonies. (*Ditto*, 610 614. Abstr. in *Ditto*, E. 89.)

91. *Bull.* No. 71 of the Assoc. Cotonn. Colon. contains an article "La production cotonnière dans les colonies françaises."

92. French West Africa. (*Text. Merc.*, 1925, **73**, 221. Abstr. in *Summ Curr. Lit.*, vol. v., **16**, 1925, E. 81.) Native production is increasing rapidly in French Soudan.

93. Le Coton à Madagascar. By V. Cayla. (*Assoc. Cotonn. Colon.*, Paris, 1925.)

94. Crop Production in Mexico. (*Int. Cott. Bull.*, 1925, **3**, 615-616. Abstr. in *Summ. Curr. Lit.*, vol. v., **17**, E. 89, October, 1925.)

95. Cotton Cultivation in Morocco. (*Ditto*, 616-617. Abstr. in *Ditto*, E 90.)

96. Cotton Production in Paraguay. (*Ditto*, 618-622; *from Deutsche Zeitung (Fiebrig-Gertz)*. Abstr. in *Ditto*, E. 90.)

97. Cotton Cultivation in Panama. (*Ditto*, 617-618. Abstr. in *Ditto*, E. 91.)

98. Cotton Production in Persia. (*Ditto*, 622-623. Abstr. in *Ditto*, E. 91.) Persia has about 14,000 acres under cotton, and all districts of Ispahan, except two, are concerned in its production.

99. Cotton Exports from Peru. (*Ditto*, 623-625. Abstr. in *Ditto*, E. 92.)

100. Cotton Growing in Salvador. By F. Choussy. (Abstr. in *Exp. Sta. Rec.*, vol. 52, **9**, p. 832.)

101. Syria: Cotton Production. (*Int. Cott. Bull.*, 1925, **3**, 402. Abstr. in *Summ. Curr. Lit.*, vol. v., **16**, 1925, E. 82.) The 1924 cotton area was 23,343 hectares—*i.e.*, double that for 1923.

CULTIVATION AND MACHINERY; IRRIGATION, ETC.

102. Economical Tillage. By Oscar Thomason. (*The Farmers' Journal*, vol. 7 **34**, p. 7.) An article in favour of mechanical rather than animal power for tillage, but pointing out what its adoption involves in greater demand for skilled labour.

103. Wind Power and Irrigation, with Special Reference to the Sudan. By A. J. V. Underwood. (*East Africa*, vol. ii., **55**, p. 53.)

104. Manuring. By J. J. Skinner and W. F. Pate. (*J. Amer. Soc. Agronomy*, 1925, **17**, 550-556. Abstr. in *Summ. Curr. Lit.*, vol. v., **17**, E. 93, October, 1925.) Fertilizer experiments with cotton on a coastal plain, fine, sandy, loam soil, formed from Piedmont material transported and deposited by stream action, are described. The experiments were made in North Carolina. From the data

obtained it is apparent that, whilst phosphate had very little influence on yield, it had an effect in the maturing of the cotton, but its influence is a minor one in comparison with that of nitrogen, which produced a vigorous plant bearing abundant fruit, or of potash, which is a *primary factor* in the metabolism of the plant, in rust prevention, boll formation and maturation. The effect of potash on cotton on this soil is unusually striking, and its influence is more pronounced than on most soils of the cotton belt.

105. Fertilizer Tests with Cotton in North Mississippi, Holly Springs Branch Experiment Station. By C. T. Ames. (*Mississippi Sta. Circ.*, 55 [1924], p. 4. Abstr. in *Exp. Sta. Rec.*, vol. **53**, No. 2, 1925, p. 136.)

106. Cotton Plant Manuring. By D. J. Burleson. (Bot. Abstr., 1925, **14**, 601, from *Amer. Fertilizer*, 1925, **62**, 48.) Phosphoric acid stimulates early growth and fruiting of the cotton plant, and also hastens maturity. A large amount of available nitrogen makes the plant grow rapidly, and gives it a dark green colour. The nitrogen should be mostly used up in the early part of the season, so that the plant will not produce excessive vegetative growth. Potash makes the plant strong and rigid, and also tends to make it resist certain diseases, such as rust. (*Journ. Text. Inst.*, xvi., **8**, August, 1925, p. A248.)

107. A Common Error in Interpreting Financial Returns from Fertilizer Experiments. By E. L. Worthen. (*Jour. Amer. Soc. Agron.*, 16 [1924], No. 12, pp. 776-781, fig. 1. Abstr. in *Exp. Sta. Rec.*, vol. **53**, No. 2, 1925, p. 119.) In a contribution from Cornell University it is pointed out that the more profitable of two fertilizers differing in cost cannot be ascertained from the results of a single comparison of an equal rate of application of the two. The method which makes comparisons on the basis of percentage return on the investment is considered to favour the less expensive of the two treatments. The common method of interpreting financial returns by comparing two single treatments, based on the net value of the crops over the cost of the fertilizer, is considered to be generally in favour of the more expensive treatment, particularly where the fertilizer applications are small.

108. Cotton Picking Machine. (E.P., 236408. L. E. Wirth.)

And *cf.* abstr. 13, 17, 26, 27, 37, 38, 40, 45, 46, 48, 49, 53-8, 63-7, 71, 74, 133.

COTTON: DISEASES, PESTS, AND INJURIES.

109. The Cotton Plantation and its Insects. By C. B. Hardenberg, Chief, Entomological Sect. Dept. Agric., Lourenço Marques. (*S. African Cotton Growers' Journ.*, vol. ii., **1**, p. 55.)

110. Insect and Related Pests of Egypt. By F. C. Willcocks. Vol. II., Insects and Mites Feeding on Gramineous Crops and Products in the Field, Granary, and Mill. (*Sultanic Agric. Soc.*, 1925.) Includes a number of insects also found to attack cotton.

111. Report on the Second Imperial Entomological Conference, June, 1925 (H.M. Stat. Off., 9d.). Delegates from most of the Governments of the Empire attended this successful and stimulating meeting. Nineteen resolutions were unanimously passed, among them being (3) recommending that conferences be also held in the Dominions and Colonies, (4) that large companies should in their own interests engage the services of entomologists, (5) that the annual revenue of the Imperial Bureau of Entomology be not less than £13,000, (10) that the Bureau should resume the exporting of beneficial parasites as soon as possible, and (17) that comprehensive measures be adopted against the tsetse fly. Ap-

pendices give reports on the work of the Imperial Bureau, and upon the discussions, among which may be specially noted "Methods of Dealing with Cotton Pests in the Sudan" (Mr. H. H. King), "Cotton Pests in Nigeria" (Mr. A. W. J. Pomeroy), and those upon organization, the qualifications of an economic entomologist, tsetse fly, and termites.

112. Control of Plant Diseases by Dusting. (*Tropical Agriculture*, vol. ii, 9, September, 1925.) From the Mycological Notes in the above journal we quote the following extract from an American journal: "Cotton dusting has developed by leaps and bounds in the last five years, the most recent development being the use of aeroplane dusters. I understand that commercial contracts for aeroplane dusting of cotton fields at $1.00 per acre for next season are now being made in one section of our southern cotton-growing region."

113. Sodium Fluoride as an Insecticide. By L. B. Ripley. (*Bull. Ent. Research*, 15 [1924], No. 1, p. 29.) The author's investigations indicate that sodium fluoride may, in a number of cases, replace arsenical poisons. Though effective, it is not so toxic as sodium arsenite either to cutworms or to brown locusts. It probably does not act as a contact poison on adult locusts.

114. Uganda. (*Report of Agr. Dept.*, 1924.) As is normally the case, aphis has been the most serious insect pest of this crop. The damage, although perhaps not so evident as that due to boll worms, for instance, can be very extensive. Trees are reduced in vigour, particularly in dry weather, and are markedly retarded in their growth through loss of sap and of food-producing leaf surface. The predator of cotton aphis mentioned in last year's report proved to be the larva of the Syrphid fly *Paragus borbonicus* Meq.

Samples of cotton seed from various parts of Uganda were obtained to determine the presence or absence of the pink boll worm; as in previous years the result has been negative.

A smooth greenish boll worm new to the collection has been found in considerable numbers in the vicinities of Bukalasa and Siroko Valley. The pupae probably occur in the soil devoid of cocoons. The adult moth is not yet identified.

In parts of Lango and Teso a pest which threatens to be of very serious status has been newly observed. This is the grub of a scaraboid beetle; it eats the more tender roots of cotton, and so reduces the area available for the absorption of water and mineral food that the plants wilt and die during periods of dry weather. Such insects, known as "root-grubs," are of major importance as pests of cereals and sugar-cane elsewhere.

115. Insect Pests. (*S. Carolina Sta. Rpt.*, 1924, pp. 43-48. Abstr. from *Exp. Sta. Rec.*, vol. 52, 6, 1925, p. 553.) Brief notes are given on several new materials, including nicotine preparations and combinations of nicotine sulphate with calcium arsenate, as tested in the laboratory with a view to discovering substances of high toxicity in a search for control measures for the cotton boll weevil and the cotton aphid. A brief reference is made to the occurrence of the Mexican bean beetle in South Carolina and means for its control.

A type of injury to cotton plants, apparently new, which appeared during the summer, was found to be very largely caused by the cotton flea (*Psallus seriatus*, Reut.). This injury was observed early in the season, when certain growers were examining cotton for the first signs of boll weevil activity. The injury is characterized by the young terminal bud and terminal leaf withering, turning black, and dropping from the plant, as a result of which the squares fail to develop. Severe infestation resulted in the failure of the plant to fruit. The damage to cotton usually occurred in rather localized areas, although more or less injury sometimes occurred throughout large fields. The insect appears to

be somewhat migratory in habit, feeding upon the more succulent plants of an infested field, and migrating to other sections after the buds of the infested area had been killed or the plant growth retarded.

116. Poisoning the Boll Weevil in the Piedmont Section of S. Carolina. (*S. Carolina Sta. Circ.* 33 [1925], p. 3. Abstr. in *Exp. Sta. Rec.*, vol. **52**, 1925, p. 857.)

117. A Progress of Boll Weevil Poisoning Work at the Holly Springs Branch Experiment Station. By C. T. Ames. (*Mississippi Sta. Circ.* 51 [1924], p. 12. Abstr. in *Exp. Sta. Rec.*, vol. **53**, No. 1, 1925, p. 56.)

118. Jassid in Zululand. (*Journ. of S.A. Dept. of Agric.*, xi., **1**, p. 9.) The area of the most severe jassid attacks extends from the northern end of the Transvaal through the low veld of the eastern part of this Province to the southern end of Swaziland. The attacks always follow prolonged periods of wet and cloudy weather, and this was again the case in the abnormally wet season experienced this year. Cotton growers are advised to grow only the more hairy varieties, which show greater jassid resistance. It was observed, however, that on one farm Watts's Long Staple, which is generally particularly susceptible to jassid, was almost unattacked; the reason for this anomaly has yet to be explained, and the influence of such factors as drainage and local soil and weather conditions needs further investigation.

119. Jassid Disease. The *Rhod. Agric. Journ.*, xxii., **5**, p. 605, contains a letter from F. H. G. describing Mr. H. S. Parry's theory that the discoloration and injury apparently directly due to the attack of jassid is really caused by a fungus of which it is the carrier.

120. Damage Done to Cotton Seed by Plant Bugs. (*Queensl. Agric. Journ.*, xxiv. **2**, August, 1925, p. 203.) An illustrated article by E. Ballard, Commonwealth Cotton Entomologist. The plant bugs dealt with in this article are: (1) the harlequin bug, and (2) and (3) the large and small cotton stainers.

121. Cotton Stainer Control. (*Austr. Cott. Farmer*, vol. i., **7**, p. 15.)

122. Mycological Work in Egypt during 1920-22. By H. R. Briton-Jones. (*Min. of Agr. Techn. and Sci. Serv. Bull.* 49, Cairo, 1925, P.T. 5.) The first 60 pages are devoted to Sore shin, with descriptions of the fungus, other host-plants (it was found to attack such plants as castor oil, sesame, pumpkin, cabbage, ground nut, water-melon, radish, carrot, and peas), the growth limiting factors (aeration, moisture, and temperature), the conditions (soil, cultivation, time of sowing, etc.) affecting it in the field, the remedial measures (treatment of the seed with naphthalene—sometimes useful—and with lime—not so), and ending with general recommendations as to cultivation, time and depth of sowing, position on ridge, rotation and drainage. The later shorter papers refer to root-rot, angular leaf-spot, wilt disease, etc.

123. Angular Leaf Spot Disease, Korea. By K. Nakata, T. Nakajima, and S. Takimoto. (*Japanese J. Bot.*, Abstr., 1925, **2**, 56; from *Bull. Agric. Exp. Sta. Chosen*, 1924, **10**, 1-21. Abstr. from *Summ. Curr. Lit.*, vol. v., **16**, 1925, E. 83.) Angular leaf-spot, a common disease of cotton grown in Korea, attacks seedlings, stems, bolls and leaves, and its prevalence is favoured by wet climate and lack of potash fertilizer. Infection is through seeds carrying the organism on their ground hairs. The organism is resistant to dryness and to heat, and is sensitive to lime-sulphur, Bordeaux mixture, formalin, etc., under conditions stated. Effective measures of control are seed treatments: hot water treatment (60° for 10 min.) and chemical treatment (0·1 per cent. corrosive sublimate for 10 mins.)

followed by delinting with commercial sulphuric acid are recommended. Observations are made on the power of resistance to the disease of fifty-seven varieties of Upland cotton, and of Chinese, Korean, and Indian varieties. The Chinese variety was found to be first in resistance.

124. An Investigation of a Sample of Diseased Seed-Cotton Sent from Nyasaland. By R. W. Marsh. (*Journ. Text. Inst.*, vol. xvi., **10**, 1925, p. T.318.) No definite connection was established between the fungal attack upon the interior of a seed and the staining of its lint. The deep staining at the base of the hairs, previously referred to, is common, but it is not confined to the lint of internally diseased seeds. No example has been seen of the outward spread of mycelium through the seed coat to the hair cells. Furthermore, the proportion of apparently healthy seeds bearing stained lint would indicate that attack upon the latter can take place independently. . . . The discoloration of the lint is due to the presence of a yellow substance in the central canal of the hairs. The appearances suggest that this substance had arisen in the developing hair as a pathological modification of the protoplasmic contents of the hair cell. There is no evident stain in the wall of the hair.

Spores of a species of *Nematospora* were found in numbers lying among the hairs and within the injured seeds. In these seeds, mycelium and sporangia of this fungus were also observed. This organism was not obtained in culture, since neither the spores nor the mycelium proved to be viable. This species of *Nematospora* is apparently identical with the fungus termed by Nowell "Species C," and described as one of the causes of the staining of cotton lint and injury to cotton seeds in the West Indies. [Paper since received from author.]

125. The Control of Damping off of Cotton Seedlings by the Use of Uspulun. By H. R. Rosen. (*Science*, 60 [1924], **1556**, p. 384. Abstr. in *Exp. Sta. Rec.*, vol. **52**, 1925, p. 747.) Watering with a solution of Uspulun was found a preventive of damping off.

126. A Disease of Cotton (trans. title). By H. A. Tavares. (*Bol. Agr.* [Sao Paulo], 24 ser., Nos. 3 4 [1923], pp. 101-109. Abstr. in *Exp. Sta. Rec.*, vol. **53**, No. 1, p. 44.) The wilt of cotton due to *Fusarium vasinfectum* is noted as to symptoms, effects, injury caused, and prevention by means of rotation and use of cotton varieties mentioned as more or less resistant to the organism.

127. Bacterial Deterioration, and Ginning, of Damp Seed Cotton. By A. C. Burns. (*Journ. Text. Inst.*, xvi., 1925, p. 185.)

128. Notes on the Soft Rot of Cotton Bolls in the West Indies Caused by Phytophthora. By J. C. Hopkins, B.Sc. (*Ann. Bot.*, xxxix., 1925, p. 267.) This disease is as yet only known in the West Indies, and only spreads after heavy or prolonged rain. Infection is presumed to be brought about by the splashing of the motile zoospores from the soil on to the lower bolls. Three forms occur, the St. Vincent, the Montserrat, and the Trinidad, and this paper describes their action on different varieties of cotton. Details are then given of methods and results, with drawings of various stages, and the paper ends with a summary: (1) At least two species of Phytophthora, one of them apparently having two strains, are responsible; (2) varying powers of virulence have been established for these fungi, and details of the relative susceptibility or resistance of six varieties of cotton described; Sea Island proved to be the most susceptible; (3) all three forms secrete a cellulose-dissolving enzyme which can cause a rot and cell-separation in the absence of the mycelium from the host tissue; (4) the behaviour of zoospores, germination of the resting spore, and growth of the germ tube are described; (5) penetration of the boll and the passage of the fungus through the host tissues are followed; (6) the rot resulting from growth of the fungus in the

tissue and that due to enzymes are compared, and the similarity between the two pointed out; (7) the possibility of control by spraying with Bordeaux mixture is indicated.

129. Studies in the Genus Fusarium. By W. Brown, M.A., D.Sc. (I., *Ann. Bot.*, xxxviii., 1924, p. 379); (II., *Ditto*, xxxix., 1925, p. 373.)

130. Cotton Boll Shedding. (*Oklahoma Sta. Bienn. Rpt.*, 1923-24, pp. 23, 24. Abstr. in *Exp. Sta. Rec.*, vol. 53, No. 2, 1925, p. 150.) In a greenhouse study of the cotton plant, cotton boll shedding appeared to be in inverse ratio to frequency of cultivation. It was heavy from six to eight days after a sudden drop in temperature, but it was not affected materially by high temperature or by slight variations. The average period of persistence (square appearance to shedding) was about 25 days. The period from the appearance of squares to blooming was from 35 to 40 days. When shedding occurred after blooming it averaged 6·5 days for the continuous fruiting branches, 6·8 for the vegetative branches, and 8 days for the short determinate branches. Fewer squares borne on short determinative branches were shed than on continuous fruiting and vegetative branches, and these latter differed only slightly between themselves.

131. Bud and Boll-Shedding in Cotton. By G. R. Hilson, V. Ramanatha Ayyar, and R. Chokkalingam Pillai. (*Pusa Bull.* 156, 1925.) As a preliminary to a detailed investigation of the problem of bud- and boll-shedding, the development of the cotton plant has been studied during three seasons, the study being limited to the aboveground portions of the plant. Plants of the Cambodia variety (*G. hirsutum*) and of Cambodia-like selections from a cross between this variety and Bourbon (*G. purpurascens*) were used.

The results are described under the heads of (*a*) bud production, (*b*) flowering, (*c*) bolling, and (*d*) shedding. Data for the following items are presented in tabular and graphic form: (1) rates of bud-production and shedding, flowering, bolling, and boll-shedding in Cambodia per plant per week; (2) interval from bud to flower; (3) efficiency in bud-production; (4) interval from flower to shedding of bolls. During the investigation the influence on shedding of insect attack became pronounced, and it was sought to estimate the proportion of shedding attributable to this cause. An analysis of buds and bolls shed by the agency of pink bollworm, spotted bollworm, and another of unknown species is presented graphically, and the relative rates of bud- and boll-shedding due to those and other similar agencies are shown. (*B.C.I.R.A.*, *Summ. Curr. Lit.*, E. 99.)

And *cf.* abstr. 50, 51, 78.

BREEDING, GENERAL BOTANY, ETC.

132. The Year Ahead: Selection of Plants and Seed for Future Crops. (*African Cotton Journal*, vol. i., 13, p. 5.) A brief account of Prof. Webber's system for the selection by the cotton farmer of his own seed.

133. The Growth of the Cotton Plant in India. I. The Relative Growth-rates during Successive Periods of Growth, and the Relation between Growth-rate and Respiratory Index through the Life-cycle. By R. S. Inamdar, S. B. Singh, B.Sc., and T. D. Pande, B.Sc. (*Ann. Bot.*, xxxix., 1925, p. 281.) The experiments described were designed with a view to obtain a comparison of (*a*) The relative growth-rate curves of plants grown in different periods of the year; (*b*) the relative growth-rates with variation in the leaf-weight ratio and the leaf-area ratio; (*c*) the relative growth-rates on the one hand, and variations in the respiratory indices of the entire plant and of its parts throughout the life-cycle on the other. Selected seeds of var. *roseum* were used, and grown separately in pots. Elaborate

details of the work are given, and it is finally concluded that the growth-rate curves show a maximum increase, reached sooner or later according to the duration of the vegetative period, with a fall at a later period. The maximum increase stimulates the formation of the reproductive organs. The growth-rate curve shows three phases: an initial when it agrees neither with the leaf-weight nor leaf-area ratios, an active when it runs parallel to one of these, and a final when it decreases more rapidly than either. The growth rate curve is compared with the course of the respiratory index throughout the period of growth, and they are found to run parallel. Detail must be sought in the original.

134. COTTON HAIR: ITS STRUCTURE. By O. Dischendorfer. (*Angewandt. Bot.*, 1925, **7**, p. 57.) The author suggests that in comparing cottons, measurements of cross-sectional area should replace measurements of staple-length, as being capable of more accurate determination.

And *cf.* abstr. 69, 70, 74, 145.

CO-OPERATION.

135. HOME RULE FOR THE COTTON INDUSTRY. (*Text. Recorder*, xliii., **511**, p. 59.) "In the report of the world's spinners' takings of American cotton up to June 12, 1925, from the 1924-1925 crop, we read that from the total takings of 13,276,000 bales Great Britain's share is 1,987,000 bales, America 6, 163,000 bales, Continent of Europe 4,240,000 bales, other countries 886,000 bales. The foregoing figures represent the following proportions of the total takings: Great Britain, 14·96 per cent.; America, 46·42 per cent.; Continent of Europe, 31·93 per cent.; other countries 6·67 per cent."

The article advocates greater co-operation in the cotton industry, and criticizes some of the methods in use.

CHEMISTRY AND PHYSICS IN THEIR APPLICATION TO COTTON PROBLEMS.

136. SOIL AND SOIL FERTILITY. (*Exp. Sta. Rec.*, vol. li., **5**, p. 401.) The editorial gives a valuable summary of the results that have been obtained in investigations on this subject.

137. STUDIES ON SOIL REACTION. III. THE DETERMINATION OF THE HYDROGEN ION CONCENTRATION OF SOIL SUSPENSIONS BY MEANS OF THE HYDROGEN ELECTRODE. IV. THE SOIL REACTION OF CONTINUOUSLY MANURED PLOTS AT ROTHAMSTED AND WOBURN. V. THE DEPTH-DISTRIBUTION OF REACTION AND FLOCCULATION IN CONTINUOUSLY MANURED SOILS. By E. M. Crowther. VI. THE INTERACTION OF ACID SOILS, CALCIUM CARBONATE AND WATER, IN RELATION TO THE DETERMINATION OF "LIME REQUIREMENTS." By E. M. Crowther and W. S. Martin. (*Journ. Agric. Sci.*, xv., **2**, 1925.)

138. NOTE ON THE AVAILABILITY OF ORGANIC NITROGEN COMPOUNDS IN POT EXPERIMENTS. 139. FURTHER EXPERIMENTS ON THE EFFECT OF REMOVING THE SOLUBLE HUMUS FROM A SOIL ON ITS PRODUCTIVENESS. By E. M. Crowther. (*Journ. Agric. Sci.*, xv., **3**, 1925.)

140. ALKALINE REACTION OF THE COTTON PLANT. By F. B. Power and V. K. Chesnut. (*Science*, **60**, [1924], No. 1557, p. 405. Abstr. in *Exp. Sta. Rec.*, vol. **53**, No. 2, 1925, p. 159.) Investigations conducted by the U.S.D.A. Bureaus of Chemistry and Entomology, co-operating, have led the authors to conclude that the alkalinity of the dew of the cotton plant is attributable, at least in part, to the presence of ammonia and trimethylamine. It has been ascertained that trimethylamine has a particular attraction for the boll weevil.

141. Studies in the Physical Properties of Soils. I. Mechanical Properties Concerned in Cultivation. By W. B. Haines. (*Journ. Agric. Sci.*, xv., **2**, 1925.)

142. The Soil, with Special Reference to Some of its Inorganic Constituents. By M. Carbery. (*Agric. Journ. India.*, xx., **4**, 1925, p. 277.) A paper read at the Agricultural Section of the Indian Science Congress, Benares, 1925.

143. The Swelling of Raw Cotton Hairs During Mercerization Without Tension. By M. A. Calvert and F. Summers. (*Journ. Text. Inst.*, xvi., **8**, p. 1233.)

144. Cotton Hair: Swelling in Alkali. By G. E. Collins. (*Journ. Text. Inst.*, 1925, **16**, T. 123.)

145. Textile Fibres and Their Identification. (*Text. Recorder*, xliii., **509**, p. 59, and **510**, p. 50.)

146. Cotton Yarn: Testing for Strength. By E. Mauver. (*Melliand's Textilberichte*, 1925, **6**, 441.) "The resistance of a cotton yarn depends on its regularity and degree of twist, average hair length, number of hairs which are of average length, number of short hairs, breaking load and cross-section of the hairs, number of twists per unit length, type of cotton, position of the fibres in the spun yarn, and treatment of the cotton during the process of manufacture. In testing yarns for strength these factors should not be considered individually. The opinion expressed by Kuhn that the number of doublings and drafts may be of influence on the strength is only partially correct." (B.C.I.R.A., *Summ. Curr. Lit.*, v., **15**, p. L. 20.)

147. Cottonseed Proteins, Isolation. By D. B. Jones and F. A. Csonka. (*J. Biol. Chem.*, 1925, **64**, 673-683. Abstr. from *Summ. Curr. Lit.*, vol. v., **16**, 1925, B. 75.) Nearly all the fatty and resinous substances and much of the pigment are removed from cottonseed kernels by extracting the ground product with benzene, thus facilitating extractions of the proteins by various solvents. Two globulins, a pentose protein, two fractions with high ash content, and a glutelin were isolated, but not a nucleic acid.

148. Comparison of the Shade of Cottons of Different Growths when Dyed Together in the Same Bath. By D. A. Clibbens and B. P. Ridge. (*B.C.I.R.A. Memoirs*, vol. iv., **6**, 1925.) The dyes used were a direct, a sulphur, and a vat colour. With all three dyes tried the lightest shade was obtained with Sea Island, and successively darker shades with Sakel, Uppers, Texas, Broach, and Oomra, in the order named.

149. Acala Cotton, Uses of. (*Text. World*, 1925, **68**, 505. Abstr. from *Summ. Curr. Lit.*, vol. v., **16**, 1925, E. 84.) It is stated that in England and in parts of France Acala cotton has been found to take a dye better than most cottons of the same staple. Most of the cotton last year averaged $1\frac{1}{16}$ inches, though there were some very large tracts in which the staple averaged $1\frac{1}{8}$ inches. Two samples examined of $1\frac{1}{16}$ inch staple were found to be good all-round cottons well adapted for both weaving and knitting yarns, and having sufficient natural lustre to mercerize well.

LEGISLATION.

150. India. Notification, *Commerce*, August 8, 1925.

(1) These rules may be called the Indian Cotton Ginning and Pressing Factories Rules, 1925.

(2) They shall come into force on the eighth day of August, 1925.

Rules are made as to the system of marking cotton bales to be employed at the various ginneries, each of which will itself use its own distinguishing mark also. The (cotton) year will be shown and also the running number of the bale.

151. Rhodesia (Northern). Government Notices No. 113 and 115 of 1925. Regulations are made directing that all seed cotton that has been classified by an inspector shall be ginned in accordance with the following instructions: (*a*) Different varieties shall be ginned separately; (*b*) the gins shall be cleaned of seed between the ginning of two different varieties. All consignments of cotton shall be accompanied by a certificate from the inspector appointed to grade cotton lint, which will show the registered mark of the ginner and the type mark assigned by the inspector.

Notice No. 115 deals with the fixing of a date by which in any prescribed area cotton plants must be uprooted and all rubbish destroyed.

152. Tanganyika Territory. Government Notice No. 79 forbids the importation of cotton seed into Ukerewe Island save with the permission of the Director of Agriculture. All seed cotton purchased must be ginned on the Island.

153. Standards for Cotton Classification in the United States and Abroad. (*U.S. Dept. of Agric. Service and Regulatory Announcements*, 92, August, 1925.) Official Standards of the United States for American Cotton Linters. (*U.S. Dept. of Agric. Service and Regulatory Announcements*, 95.) The official statement on the subject of cotton standards and linters standards.

154. Cotton Legislation. (Editorial in *Agr. Journ. India*, xx., 5, September, 1925.) Pointing out the principles—providing for the control of the trade by the trade—which have been followed in drawing up recent Indian legislation. Systems of marking are provided that enable the history of every bale to be traced, compulsory statistics of ginning and baling are required, importation of outside cotton into a district can be prevented by proclamation, and so on. The article should be read by all interested in cotton legislation.

MISCELLANEOUS.

155. The Cotton Trade's Essential Need. By Sir Charles Macara, Bart (*Text. Recorder*, xliii., 511, p. 52.) In the first paragraph the author states that what is wanted is "confidence in ourselves and breadth of vision, together with a realization that we are subject to world contingencies over which we have no control." He then proceeds to explain this in more detail, with special reference to the bogy of Italian and other competition.

156. The Cotton Industry. By S. S. Hammersley, M.P. (*Text. Recorder*, xliii., 511, p. 55.)

157. Essential Need of the Cotton Industry: The Raw Material Supply. (*Text. Recorder*, xliii., 511, p. 55.)

158. The Shipping Merchant in the Cotton Trade. (*Text. Recorder*, xliii., 511, p. 93.) A defence of the merchant, whose functions are defined as the supply of capital and knowledge.

159. THE COTTON TRADE. By C. J. Homewood. (*Journ. S. Afr. Dept. Agric.*, xi., 2, p. 115.) An elementary account of the British trade and its methods.

160. SKINNER'S COTTON TRADE DIRECTORY OF THE WORLD, 3rd edition, 1925-26. (Skinner and Co. 1925. 25s. net.) A much enlarged edition (2,400 pages) of this most useful work has just appeared. For those who are unfamiliar with it, it may be well to explain that it is international, and contains very complete lists of merchants, brokers, exporters, spinners, agents, dyers, finishers, and of all who have to do with the cotton or artificial silk trade, arranged by countries and towns. This is followed by classified lists of manufacturers of various fabrics, machinery, electrical and chemical articles, etc. All indices, etc., are given in six languages. To anyone who may have occasion to require to refer to people engaged in the trade, the book is simply indispensable, and its price is very moderate.

161. THE BRITISH COTTON INDUSTRY: SURVEY AND PROSPECTS. By G. W. Daniels. (*London and Cambridge Econ. Serv.*, Special Memo., October 14, 1925.) The outstanding features of the British cotton trade are its dependence upon foreign countries for supply of raw, and sale of manufactured, material. Table I. gives a useful summary of exports year by year, expressed in percentages of the export of 1913, the highest since reached being 74 per cent. (of piece goods) in 1916, and 96 per cent. (of yarn) in 1922, though the value is greater. The depression in trade is put down more to the falling off in piece goods than in yarn. The decrease in yarn shows chiefly in the lower counts, in which our trade has to meet keener competition. The Indian imports of yarn, 86 per cent. from the United Kingdom and 2 per cent. from Japan in 1913-14, were in 1924-25 37 per cent. and 58 per cent. respectively, the decrease chiefly in the lower counts. In Table V., the percentage distribution of piece-goods exports, it is seen how the Far East is falling off (from 61·6 to 46·4 per cent. of the total) while the rest are gaining. The European Continent shows a gain from 5·2 to 9·6 per cent., the self-governing Dominions from 5·6 to 7 per cent. When expressed as quantities (Table VI.) the result shows that Europe and the United States alone have increased their takings. The shrinkage in the imports of the self-governing Dominions is mainly due to the less demand from Canada. Many further tables then deal with the individual markets one by one. The whole gives a very clear survey of the course of British trade, indicating what are the general tendencies and the objects at which (perhaps) to aim, and ending with a discussion of the short time policy. It should be in the hands of anyone interested in the cotton trade as a whole.

162. A NEW ERA IN THE COTTON TRADE. By W. Wilkinson. (*Text. Recorder*, xliii., 510, p. 79.)

163. COTTON TRADE FORECASTS. (*Textile World*, 1925, 68, p. 1335.) The summary of market indications to August . . . *i.e.*, . . . (1) the tendency of raw cotton is to stabilize at a somewhat lower level . . .; (3) mill consumption is increasing . . .; (4) the decline in spindle activity has spent itself . . (*B.C.I.R.A.*, *Summ. Curr. Lit.*, M. 57.)

164. VISCOSE SILK: THEORY OF MANUFACTURE. By R. O. Herzog. (*Papier-Fabr.*, 1925, 23, *Fest- und Auslandsheft*, p. 115.) Those who desire to know something of the processes involved in the making of viscose silk will find a long and readable abstract of this paper in the *B.C.I.R.A. Summ. Curr. Lit.*, v., 19, p. C. 126.

165. REPORT OF THE COMMITTEE OF THE PRIVY COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH, 1924 25. (London, 1925, 3s. net.)

166. B.C.I.R.A.: Report of the Sixth Annual General Meeting, September 15, 1925. Continual progress is being shown by the work of the Shirley Institute, where eighty-five workers are now employed. Dr. Crossley's report of the research work shows various features of interest. The part played by the different structural features of the hair in mercerization has been almost completely elucidated. The subject of mildew has been investigated in detail, and much useful knowledge gained. Much work has also been done upon yarns, machinery, sizing, scouring, bleaching, dyeing, finishing, and other subjects which are not of direct interest to growers of cotton.

167. The Place of Cotton in Land Settlement. By A. G. Owen. (*Afr. Cott. Journ.*, i., July 8, 1925, p. 29.) Cotton is of great advantage as providing an export crop.

168. Report on Economic and Commercial Conditions in Turkey. (*Dept. Overseas Trade*, 1925.)

169. Bibliography of Books and Papers Relating to Ceylon Agriculture and Botany to the End of the Year 1915. By T. Petch. (*Peradeniya Manuals*, iii., Colombo, 1925.)

170. Imperial College of Tropical Agriculture. (*Trop. Agriculture*, vol. ii., **9**, September, 1925.) In the September number of *Tropical Agriculture* is a supplement containing a report of a Deputation to the Secretary of State for the Colonies to urge upon him the claims of the College to be placed on a firm financial basis.

171. The Utilization in Industry of the Short Cotton Fibres on the Cotton Seed of Commerce. Apropos of abstract 578, in *E.C.G. Review*, October, 1925, p. 37, Mr. de Segundo calls attention to the fact that the machine there described has no saws, and thus does less damage than the ordinary delinting machine. Also the ordinary chemical treatment destroys the short fibre, which has a distinct commercial value.

172. Cotton Linters. By W. W. Chase. (*Textile World*, 1925, **68**, p. 1479.) A general article on the production, uses, and bleaching of cotton linters. (*Summ. Curr. Lit.*, ix., 111.)

173. Cotton-seed Oil. By G. S. Jamieson and W. F. Baughman. (*Journ. Oil and Fats Ind.*, 1925, **2**, p. 301. Abstr. in *Summ. of Curr. Lit.*, vol. v., **16**, 1925, B. 74.)

174. Value of Cotton Seed for Dairy Cows. (*Journ. Dept. Agric. for S. Africa*, vol. xi., **3**, p. 279.) "Owing to the value of the oil contained in the seed, the entire seed is not used to any extent for feeding purposes nowadays. Cotton seed has almost entirely been replaced by cotton-seed cake or meal, from which most of the oil has been extracted.

"The following table gives the comparative values of cotton seed and cotton-seed cake:

Average Percentage Composition.

	Water.	*Ash.*	*Crude Protein.*	*Fibre.*	*Nitrogen free Extract.*	*Fat.*
Cotton Seed	9·4	4·6	19·5	22·6	24·9	19·0
Cotton-seed cake	7·5	6·2	44·1	8·1	25·0	9·1

It "will be observed that cotton seed is very high in both fat and fibre. Owing to the high fat-content, cotton seed tends to produce digestive trouble. For this

reason it should be fed in limited quantities. The seed should, of course, be crushed before feeding.

"Cotton-seed cake or meal is a very good nitrogenous concentrate for dairy cows, and it is generally a fairly cheap source of protein, of which it contains a high percentage. It is better to feed the cake or meal instead of the seed itself."

175. COTTON: SPONTANEOUS COMBUSTION. By L. A. Le Moine. (*L'Avenir Textile*, 1925, **7**, p. 166.) The supposition that it is due to sparks flying when banding the bales is shown to be groundless.

176. OPERATIONS AGAINST TSETSE FLY. (*Rhod. Agric. Journ.*, vol. xxii., **6**, p. 634.) An experiment which has for its object the driving back of tsetse fly in the Lomagundi district has been sanctioned by the Government, and is being carried out under the direction of the Chief Entomologist. During the past few years fly has been encroaching in the northern area of the Lomagundi district. An amount of £3,000 has been authorized by the Government, and the scheme in brief is to create a buffer area between the occupied farms and the fly zone through which it is hoped the fly will not penetrate.

PERSONAL NOTES

Mr Sampson, the senior representative of the Corporation [illegible] has decided that the time has come for him to [illegible] and has tendered his resignation. The Corporation ha[illegible] with very great regret, and Mr Sampson accordingly will not return to [illegible]. He has rendered the cause of cotton growing and of agriculture [illegible] possible service, and his influence has extended [illegible] land border. His insistence on the necessity of a proper [illegible] and his familiarity with Indian agricultural practice have [illegible] of the greatest service to agricultural development. Mr Sampson will leave [illegible] be regretted by all, and his influence will long survive.

OFFICERS ON LEAVE

When an officer of a Colonial Department of Agriculture (or of the allied departments of Irrigation, Transport, etc.) comes "home" on leave, he usually brings with him much information that may be of considerable value to similar officers in other colonies, or to the officers of the Empire Cotton Growing Corporation, who have to collect, collate and use all possible information relating to cotton. The Corporation would consequently much appreciate the courtesy if Directors of Agriculture and others would be so kind as to inform them in advance, if possible, of the names, probable addresses, and approximate dates of arrival in England of officers coming on leave. This would give the Corporation the opportunity of getting into touch with these officers themselves, and of giving the latter the opportunity of meeting with one another. A further courtesy would be conferred if the officers themselves upon arrival would call at, or inform, the offices of the Empire Cotton Growing Corporation, which are at the corner of Millbank and Wood Street (entrance by the first door in Wood Street), immediately opposite to the office of the Crown Agents for the Colonies.

At the date of writing the following officers are on leave in England from cotton growing countries:

Gold Coast	Mr R H Bunting
" "	Mr W L Lushbrook
" "	Mr A C Miles
India	Mr W Youngman
Nigeria	Mr D H Urquhart
Tanganyika	Mr A Pitcairn
Uganda	Mr R T Wickham

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THE EMPIRE COTTON GROWING REVIEW

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OPENING OF THE LOUIS TRICHARDT COTTON GINNERY (TRANSVAAL) ON WEDNESDAY, OCTOBER 28, 1925, BY GENERAL KEMP,

MINISTER FOR AGRICULTURE, UNION OF SOUTH AFRICA.

(Translated).

IN his preliminary remarks the Minister stated that the opening of the Louis Trichardt ginnery marked an important stage in the development of the Northern Transvaal. After some references to Potgieter and Louis Trichardt, who were the pioneers of our civilization in the far north, and to the difficulties which were encountered, and after paying a tribute to the people of Zoutpansberg, the Minister proceeded as follows:

"The Spelonken Cotton Syndicate can to-day be considered as the pioneer of cotton-growing and ginning in the Northern Transvaal. This Syndicate has spent about £20,000 on the Klein Letaba. Notwithstanding the failure of the operations of the Syndicate during the past three or four years on the Klein Letaba, owing to causes over which it had no control—namely, insects—the Directors have so much faith in the cotton-growing possibilities in the Zoutpansberg that they decided to continue, although the locality of their operations had to be shifted from the Klein Letaba to Louis Trichardt and the farm Una, twenty miles west of the town. A great sum of money has been sunk in Una.

"Mr. McGregor, the Manager of the Syndicate, a man who has had a great deal of experience in farming in general and cotton culture in particular, has so much faith in your area that he has persuaded his Directors to spend a further £16,000 in the erection of a large cotton ginnery at Louis Trichardt. He deserves great

credit for his characteristic Scotch, or shall I say, real South African, Louis Trichardt, energy.

"The ginnery, which is the twenty-fourth registered cotton ginnery in the Union, is a monument in the chequered history of Zoutpansberg, and of the faith which you have in the possibilities of this huge, practically untouched, beautiful district of the Union.

Insects.

"As I have stated, the operations of the Spelonken Cotton Syndicate had to be transferred from the Klein Letaba to Louis Trichardt and the farm Una owing to the devastation of insects, in particular of boll worm. The question of insects is of such a serious nature for the whole of the cotton industry that I have now made provision for five entomologists to tackle the problem in real earnest. Two of these are already giving their whole time and attention to this matter. Unfortunately I am experiencing the greatest difficulty in filling the other three posts for which provision has been made; I have cabled to England and elsewhere, but up to the present have not succeeded in getting qualified persons for this work.

Experts for the Northern Transvaal.

"Difficulty has also been experienced in getting qualified cotton experts who have a scientific and university training. When I heard of Mr. F. M. du Toit, who has just completed his studies in agricultural science, and more particularly in cotton, I cabled to him to America, and offered him a position in the Cotton Division of my Department, with a result that he is now stationed at Louis Trichardt in order to serve the farmers in the Northern Transvaal. It is up to you to make use of him.

Seed Question.

"During the past few years we have had many complaints as regards the purity of our cotton seed. In this matter I have also taken steps to solve the problem once and for all. On the Rustenburg Experimental Farm from twelve to twenty tons of pure bred cotton seed are now grown annually. In order to make the best use of this seed, ten experienced farmers only have been selected in order to grow and multiply this seed under the supervision of my cotton officials. The ginning and the sale of the seed thus multiplied will be controlled entirely by the Chief of the Tobacco and Cotton Division. Within

two years I hope that this problem will at least be solved for the large middle veld cotton areas. The seed work for the low veld, however, has only just been started during the past season, and it will, therefore, take a few years longer before the seed question for the low veld areas will be solved altogether. The Zoutpansberg district has been granted two seed farms which will be controlled by the Cotton Division. One of these is situated on the farm Sweetwaters belonging to Mr Henning, and the other on the farm Una belonging to the Spelonken Cotton Syndicate.

Cotton Fertilizer Plots.

"As the Department is anxious to get further information about the requirements of the cotton crop in the widely scattered cotton areas of the Union, areas in which the soil and climate are totally dissimilar, I have given instructions that this work should also be tackled. A certain sum of money has been put aside for eighteen series of fertilizer plots throughout the whole cotton belt of the Union. Two of these series of plots have been put down for Zoutpansberg. A start has already been made with these. These experiments will be continued for a period of five years and may be extended for a further period of five years. This work is slow and requires much time and trouble. On this account the plots have been chosen with a view to their accessibility, and also that they may be properly controlled by the cotton officials of the Department, at the least expense. The results will be invaluable to all cotton growers as well as other farmers.

Empire Cotton Growing Corporation.

"In opening this ginnery I would like to make mention of the hearty support I have enjoyed from Sir James Currie, the Director of the Empire Cotton Growing Corporation in London, and the officials under him. He saves himself neither trouble nor expense to assist my Department in every possible way. Mr. Milligan, the representative in South Africa of the Empire Cotton Growing Corporation, has been very helpful to me. It is a pleasure to mention the great harmony which exists between him and Mr. Pieter Koch, the Chief of the Cotton Division. The relations between the officials of the Empire Cotton Growing Corporation and the officials of the Tobacco and Cotton Division have been, and are still, most cordial. The splendid co-operation that exists between these two bodies of men augurs well for the future of the cotton industry in South Africa.

South African Cotton Overseas.

"Our cotton enjoys a good reputation overseas. However, during the last few months there have been several complaints about a few shipments. Some of the cotton is 'neppy' and poor. This question has been investigated and it has been found that the 'nep' is a result of the immature and weak fibre, which in turn was caused by the continuous heavy rains and misty cool weather during the past abnormal season. Even the most experienced ginners could not have ginned the cotton much better, as such a large percentage of the fibre was so weak.

"Then complaints reached me about a small shipment of bales to Liverpool. These were falsely and cross packed. This matter also I have thoroughly investigated and find that the shipment consisted of about five bales. The original samples submitted to the Government Cotton Grader were quite uniform, but false and cross packing took place at the ginnery. The owners of the ginnery are naturally quite prepared to pay the buyers the difference in price. False packing of a bale is the fault of both the farmer and the ginner. The farmer should be more careful in keeping the different pickings apart; stained and dirty cotton should not be placed in the same woolpack with clean cotton; frosted cotton which is, as a rule, immature, should also be kept separate, as it is of much poorer quality than properly mature cotton, even though the former may be beautiful and clean. You know yourselves what the result is of mixing the different pickings—the price for the whole crop according to the poorest cotton in the crop. The managers of ginneries, on the other hand, should take more trouble in mixing seed cotton of more or less the same quality more thoroughly before it is put through the gin in order that a uniform, even running staple may be produced. We still have to learn more in this respect. During the past year we could not assist the ginners except by correspondence, as I have had only one grader. So as to get over the difficulty to some extent, I have just appointed Mr. Hoyle, a cotton grader of Liverpool. He has already commenced work; I, therefore, trust that the position will be better during the coming season. The Department has also granted three grading scholarships to young South Africans. In three or four years from now we ought, therefore, to be well supplied with graders.

Grading in the Union.

" Cotton grading in the Union is carried out more efficiently than in practically any other country in the world. This is not idle talk, it is a fact. The system of grading brought into operation three years ago by the Cotton Division is so perfect that Dr. Webber of America, one of the greatest authorities on cotton, recently remarked in all earnest, that it would pay America to send some of her experts to the Union in order to study our system of grading. Under our system every bale of cotton has to be graded by the Government Cotton Graders, and a certificate of quality issued before it can be exported. This system gives every satisfaction.

Difficulties in Marketing.

" The crop in America is so large, approximately fourteen million bales, that it controls the whole cotton market, and we can do very little with our comparatively small quantity of cotton—namely, fifteen thousand bales last year—to influence the prices. There have recently been difficulties in connection with the cotton market in Durban. However, there is no question of a sudden cessation of the Durban Cotton Market. This season has been an exceptional one, in so far as the grading of the crop has been far below the average of previous seasons. Right through the season good colour, high grade cotton has been conspicuous by its absence. Instead, big quantities of indifferent colour cotton of mediocre grade and somewhat wasty staple have flooded the market. There can be no doubt whatsoever that it is mainly the excellent colour and high grade of our usual production that has drawn buyers to our shores. The world's production of this style of cotton is relatively small, and consequently there has been keen competition for our cotton. At the beginning of our selling season we had a full strength of keen buyers and very little of the cotton they wanted. They showed little interest in the yellow spot and tinged cotton, with a result that the competition was exceptionally poor. The better class cotton, however, found a ready sale at good prices. There are several other temporary unfavourable factors which I need not discuss at present, as I hope shortly to discuss these difficulties fully with my officials in order to see whether an improvement cannot be brought about.

QUESTION OF PAYMENT.

"The Department is continually being asked to make advances to individual cotton growers. Firms and others are now sending their cotton direct to Liverpool, with a result that in some cases the producers do not get immediate payment. The way out of the difficulty, of course, is co-operation, and co-operative societies can obtain advances from the Land Bank. The remedy is, therefore, in the hands of the farmer himself.

PROGRESS OF THE COTTON INDUSTRY IN THE UNION.

"Considering that the cotton industry in South Africa is still very young, it is gratifying to note the steady progress we have made. In 1911 the production in the Union was approximately fourteen thousand pounds lint; in 1916 it was about a quarter of a million pounds; in 1921 it was one and a quarter million pounds, and this season, in spite of the drawbacks, seven and a half million pounds. This is most encouraging. Unfortunately, as stated before, much of this year's cotton is very poor, but with an ordinary season we are sure to produce the usual high grade cotton of the past few years.

"During the past year approximately 85,000 morgen were planted to cotton. This is only the beginning. There are about 2,000,000 morgen in the Union and Swaziland suitable for cotton. We have firm hopes that the cotton industry is destined to become one of the greatest agricultural industries in the Union.

"Our Sister State to the north of the Limpopo and also our neighbour on the eastern border are going ahead by leaps and bounds, and together we should produce a considerable quantity of cotton in the very near future.

"At present there is a great shortage of cotton throughout the whole world. Production is a matter of life and death to the many spinners in England and on the Continent. Cotton they must have. We now have an opportunity of which we must make the fullest use.

"I can give you the assurance that the Government is greatly interested in the development of the cotton lands in the Union. From what I have already said you can see that I am doing my utmost to meet, as far as possible, any reasonable demands.

"May the cotton industry in South Africa develop rapidly and be of a permanent nature, and may it contribute to making our South Africa in general, and the Zoutpansbergers in particular, happy and prosperous.

"I now take great pleasure in declaring the Louis Trichardt Cotton Ginnery open."

THE FUTURE OF COTTON GROWING IN QUEENSLAND

BY

G. EVANS, C.I.E., M.A.,

Director of Cotton Culture, Queensland.

THE history of cotton-growing in Queensland during recent years has been dealt with by the writer in a recently published article.* Ample evidence has been collected during the last few years to show that certain parts of Queensland are admirably adapted to the production of Upland American cotton of excellent quality, so far as the soil and climatic conditions are concerned. Although much of the land that was painted with a broad brush as cotton territory during the boom days will be found to be not really suitable to this crop, yet the area that remains undoubtedly amounts to many thousands of acres and forms one of the largest potential, but as yet undeveloped, cotton-producing areas in the world. It will be interesting, therefore, to examine closely the progress made by the industry during these last three years and at the same time to endeavour to assess at their true value the various economic or other factors that may tend to stimulate or retard development. In other words, is Queensland rapidly going to assume a prominent place as a really important cotton producer, or is development likely to be a slower and more gradual affair?

VARIABLE CLIMATE NECESSITATES INTELLIGENT FARMING METHODS.

One of these factors is the variability in the climate. The three past seasons have been totally unlike each other. The 1922-23 season commenced with fair spring rains, enabling planting to be undertaken at the right time and under favourable conditions. The season continued favourable until the New Year, but afterwards the rains failed and a long drought ensued which was not broken until the following November. Good general rains fell towards the end of that month and in December. January was generally hot and dry,

* *Empire Cotton Growing Review*, vol. ii., No. 3, p. 169.

but excessive rain fell throughout February and March and caused a good deal of damage, many of the crops going too much to wood. The 1924 spring, besides being colder, was also wetter than usual, and consequently many growers who were not well equipped with the necessary implements found it difficult to keep the young crops clean and free of weeds. The wet spring also caused the cotton plants to be shallow-rooted, with the result that in February, when a heat wave of exceptional duration and severity occurred, they were in a poor condition to withstand its effects, and a good deal of shedding and premature opening of the bolls resulted. In some parts good rain fell after the heat wave and the plants recovered and set a new crop, but in other areas only light, scattered showers fell, which tended to stain the open cotton without adding to the soil moisture. Early frosts occurred in the more inland areas in the third week of April and damaged the top crop.

Sufficient has been said to show that the climate is variable and that there are no set rainy and dry seasons. India has its monsoons, and even in Australia parts of the Northern Territory and the Cape York Peninsula of Queensland have a fairly regular wet season. It means, therefore, that if cotton is to be successfully grown in Queensland, careful and intelligent methods of farming must be employed. Early preparation of the ground to include a winter fallow, with a view to the utilization of any cold weather rains that may fall, and the proper preparation of the seed bed, are essential. Further, the correct distance for spacing and frequent inter-cultivation are other common-sense precautions against the spells of drought of varying duration that may be anticipated, and which must inevitably therefore be guarded against. That these methods are both practicable and possible is proved by the fact that excellent yields have been obtained both on the experimental farms and by experienced farmers during the last three seasons. Unfortunately, really experienced farmers are at present comparatively few and far between in the Queensland cotton belt, and many of the cotton-growers consist of ex-miners, professional men, tradesmen or artisans from the Old Country or the Australian towns. Many are also graziers who have been compelled to try their hand at farming owing to the slump in cattle prices. Not only have these men not sufficient knowledge of tropical farming methods, but they are often lacking in capital, and are usually not well equipped with implements. The somewhat haphazard methods adopted by these people have met with the inevitable results, and they have not obtained the financial returns that they were led to expect by land agents and others who interested themselves in the

cotton boom of 1922. One of my chief objects, after I had had the opportunity of summing up the situation, was to set to work to correct this state of affairs. Obviously the only thing to do was to devise some method of imparting the necessary knowledge to these potential cotton producers. It was accordingly decided to recruit the best trained men available as field assistants. Their duty would be to visit the various growers, get them to prepare their land early, to avoid certain classes of soil and to choose the right land. Methods of planting, seed rate, the correct time to thin out, spacing, and the necessity for frequent inter-cultivation have all had to be practically demonstrated in the field. I consider myself fortunate in the personnel that I managed to secure for this important work. The whole of the staff selected were practical agriculturists who had passed through one or other of the Agricultural Colleges that exist in various parts of Australia. The result of their efforts has been very noticeable this year, and the growers, as a whole, have now a much better idea about certain of the fundamental facts of cotton-growing than they had three years ago. The number of trained men available is, however, so small, the distance to be covered so great, and the cotton plots so widely scattered, that progress is bound to be more or less gradual. Nevertheless, steady improvement is being achieved, and those growers who have stuck to the land and not become disgusted with their poor results during the last two or three years are undoubtedly in a much better position to grow the crop.

Ratooning.

The unfortunate controversy about ratooning was really based on a misconception. Certain of the self-styled "cotton experts" that swarmed in Queensland, and included men from every walk of life whose chief distinction seems to have been a lamentable lack of knowledge of cotton-growing, spread the notion abroad that cotton if ratooned was drought resistant, did not suffer from pests, and required the minimum amount of work. This naturally sounded most attractive to that class of grower who, not being previously an agriculturist, was led to believe that he was going to "get rich quick" by growing cotton. When I arrived in the country, a Bill prohibiting the ratooning of cotton had already been drafted by the State Government, largely as a result of a visit by a cotton-growing delegation headed by Mr. Crompton Wood, which had just left. The Premier had also announced that no more ratooning would be allowed after the 1922 season came to an end.

The terrific outcry that followed when this Bill was passed by Parliament is recent history. It is sufficient to say that the Local Government found it politic to repeal the Act within a few months of it becoming law. The damage that has been done is considerable, and the industry will take some time to recover from it. As a result of repealing the Act, the majority of the cotton-growers ratooned a portion of their crop. The wise ones only ratooned a small portion, others ratooned the whole and planted no fresh seed. The result has been interesting in that the wet spring prevented the proper cultivation of the ratoon cotton owing to its spreading habit of growth, except on very small areas where the crop could be worked by the hoe, but only at an excessive cost. The sequel has been that large areas of ratoon cotton have been beaten by the weeds and summer grass and are now lying abandoned. It is not difficult to imagine that if the labour that had been put into ratooning had been devoted to increasing the area under plant cotton, which this year has probably yielded nearly twice as much per acre as the ratoon, our crop this year would have been about fifty per cent. greater and the quality immensely superior. As it is, this season's crop will probably be about 11,000 bales.

This year's experience has at any rate convinced the growers that ratooning is not such an easy matter as they were led to believe. Experience has shown that a ratooned crop needs to be cultivated just as carefully as plant cotton if a decent yield is to be obtained, and that if this is done it actually costs more to bring the crop to harvest. The ratoon cotton, curiously enough, suffered more in the dry spell of December and during the February heat wave than the annual, as has been proved by boll counts, and also suffered from pests, as Mr. Ballard in a recent report has proved. The relative failure of the ratoon crop may have caused a few men to abandon their holdings in the Rockhampton and Dawson Valley areas. It is mostly those, however, who are not acquainted with farming methods who have gone. The whole controversy, unfortunate as it has been in many ways, has, at any rate, brought one fact to the front, and that is that cotton requires just as careful farming as other crops, and that the old cursory methods formerly advocated are not practicable. Personally, I am convinced that the practice of ratooning will gradually die out over the greater part of Queensland. In the scrub areas, where newly felled blocks are being burnt and brought into cultivation, it may persist, but the pink boll worm and higher picking costs will, I think, render it unprofitable. On ploughed land and forest country generally, I believe that the method of planting fresh seed each year

will prevail, more especially when cotton is bought on quality in accordance with its actual merits and not merely on a Government guarantee. On certain classes of soil and in certain of the drier inland belts ratooning may persist here and there, but it is bound to act as a "carry-over" for pests, and the amount produced is not likely to be large. I do not see how it will be possible for ratoon cotton in Queensland to be grown on a large scale under existing economic conditions.

Costs of Production.

This important point is one that is being carefully investigated, and the figures that it is hoped will shortly be available from the Cotton Experimental Farms, where accurate costs per acre are being worked out, should prove instructive.

The cost of bringing the crop to harvest varies with the class of land, season, and other factors. On scrub country the costs are different from those on forest land. "Scrub," it may be explained, is the term given to country covered with dense "rain forest," comprising various species of soft-wood trees with a thick undergrowth of bushes and shrubs. Forest land is open country with little or no undergrowth and covered with more or less scattered trees of hard-wood varieties, mainly eucalypts.

The custom in the scrub country is to fell the timber and undergrowth in the winter months and then, when dry, to fire the whole. A crop is then sown by hand in the ashes between the charred stumps that remain. One of the favourite crops to be so planted is cotton. On certain classes of scrub soils excellent crops of cotton have been obtained which have gone a long way to place the new settler on his feet and have much more than paid the cost of clearing the land. The trouble is that in the second year he cannot plough out his cotton because of the stumps, and also he cannot usually afford to employ labour to help him to cut down and burn his bushes at the right time. The result is that the second year crops, especially near the coast and in a normal spring, get choked with weeds because no horse implements can be used to keep them down. The second year crop, therefore, may prove unprofitable to pick and be abandoned. Large areas of these abandoned ratoon cotton plots are seen in the scrub areas of the Central District, and they must inevitably serve as a breeding ground for pink boll worm and other pests. The real facts are just beginning to be appreciated by the growers, and it is a matter for consideration whether in the near future it will not be found better

to plant the newly burnt scrub with maize or some other crop, or to put it down to Rhodes grass as a grazing paddock straight away. In any case it is the endeavour of the new settler to plant Rhodes grass eventually as a fodder for his dairy cows, and cotton is often only regarded as a means of covering expenses on the cost of felling and clearing the land, and of giving some profit as well during the difficult first year on a new holding.

Since the cost of felling and clearing is about 30s. to £2 per acre, and planting and thinning out comes to perhaps another 10s., the total cost of bringing the crop to harvest is not excessive, more especially as after a clean burn weeds do not cause trouble to the cotton in its first season. This method is interesting in that it is almost identical with that employed by certain primitive tribes in the jungles of various parts of India. The Gond and the Korku of the Central Provinces forests have their "dhaiya" cultivation for millets, and the natives of the Chittagong Hills practise "jhooming," in which they grow a very coarse short stapled variety of Assam cotton. After the second year, however, the clearing is abandoned to the weeds and bamboos and a new piece of forest is tackled.

It is likely that cotton in Queensland will in the future tend to be produced more and more on soil that has been brought under the plough, and it is therefore important to study the costs of production on this class of land. Various estimates have been made of the cost of bringing a crop to the harvesting stage. On an average, and for the purposes of estimation, £4 an acre may be taken as a fairly representative figure, if anything perhaps a shade on the low side. The yields vary greatly, both in accordance with the season and also with the methods of the individual grower. This year, for instance, on the Monal Creek Demonstration Farm on the Upper Burnett an average of nearly 1,500 lbs. of seed cotton over twenty-one acres (some of which was late planted as an experiment and was severely damaged by the early frost) was obtained. The portion planted in October actually yielded at the rate of 2,200 lbs. per acre. These figures are, of course, exceptional, and although several of the new settlers near this farm who adopted the farm methods obtained practically as good results, other districts, of course, did not fare so well. In some places the rains were not so favourable and the heat wave did more damage, whilst in other areas pink boll worm and boll rots were more pronounced. Of the area actually brought to harvest this year and not reckoning the abandoned areas, it is fairly safe to say that a crop of 700 lbs. of seed cotton per acre was obtained as an average.

The cost of bringing this to rail head will be approximately as follows:

	£	s	d.
Cost of bringing an acre to harvest	4	0	0
Picking 700 pounds at 2d per pound	5	16	8
Haulage, bags, picking, rent, etc.	1	1	6
Total	£10	18	2

This latter item naturally varies in accordance with the distance from the railway, but the figure given above may be taken as an average.

This works out at 3·74d. per lb. of seed cotton or for the sake of ready reckoning 11·25d. per lb. in the lint, since the ginning percentage works out at somewhat less than 33 per cent. in actual practice.

The other charges have been estimated as follows by the Accountant to the Department of Agriculture and Stock, Queensland, and are based on the 1923-24 crop return, which was about 9,800 bales of 500 lbs. each:

Estimated Cost of Putting One Pound of Lint on Liverpool Market.

	d.
1. Grower's cost of production	11·25
2. Inward cartage on seed cotton	0·0001
3 Inward freight on seed cotton	0·3298
4. Ginning and handling charges	1·25
5. Insurance land risk..	0·0671
6. Wages of weighers and graders	0·1022
7. Postage	0·0068
8. Freight and other shipment charges, overseas expenses, and handling charges	1·0
9. Treasury interest	0·686
Total	15·592

It should be noted that items 2, 3, 4, 5, 6, and 7 are actual costs. Items 8 and 9 are estimates, since the final accounts have not yet quite been balanced, but they may be accepted as very nearly correct.

It will be noted that ginning and handling charges are rather high compared with other countries. This figure, however, is the rate allowed to the British Australian Cotton Association in their agreement with the local Government, which is not to terminate until the end of July, 1926. No value has been placed on the cotton seed produced in this estimate. If this were done the costs under the head "ginning and handling charges" might possibly be materially reduced. In other countries the grower usually sets the value of his cotton seed against ginning costs. In Australia the value of cotton

seed is as yet small, but may be expected to appreciate in the nc futuro.

Items 7 and 8 seem to be high, and it should be possible to redu these figures when the industry settles down and gets on to a bett organized basis. At present there is a lot of delay after the cott is ginned and before it reaches Liverpool. Again, a good deal of t crop was not disposed of until after it had been in Liverpool f several months. This, of course, partly accounts for the high intere charges.

Grading.

For the first two seasons after the revival in cotton took plac little attempt at grading was made. This was unfortunate in ma ways. The grower naturally got the impression that all cotton w approximately the same value. The slovenly grower and produc of short, dirty cotton realized the same price for his product as t grower of good cotton. The result was that there was no encourag ment to farm better or to pick a clean grade. It was soon evide that this state of affairs could not continue, since not only was Gover ment losing a lot of money on its guarantee, but the growers we getting a wrong idea about the cotton industry, which would be bou to have a disastrous effect when Government control ceased and t crop had to be sold on the open market.

Soon after my arrival, therefore, the Government agreed to secu the services of a trained cotton classer from Liverpool, and since th time a rational system of grading and classing seed cotton has be gradually evolved.* This process has naturally been a gradual on as local men had to be recruited and trained in the work. Up to t present a system of grades based on the universal standards h been enforced, and a schedule of prices adopted in accordance wi the grades only, but after this season it is probable that a simp set of staples will be introduced also, since the new graders have n become sufficiently experienced in this art. As was only to be e pected, the introduction of grading methods has caused a certa amount of indignation amongst some of the growers. This was natu after they had been accustomed to obtain high prices for their se cotton irrespective of grade or quality. Whilst grading is not popul however, I believe that the worst of the agitation has now been g over, and many of the best growers have accepted the situation an in fact, recognize that cotton has to be graded and classed if t

* Vide *Empire Cotton Growing Review*, vol. ii., No. 2, p. 121, "Cotton Gradi in Queensland," by G. Evans and L. L. Gudge.

industry is to be placed on a sound footing. The results obtained in grading wool, butter, and other products have been so beneficial that popular opinion is in favour of cotton classing. It is only the individual grower who complains.

The Need for Good Seed.

The figures for cost of production indicate that a Queensland grower at the present time would have to get between 15½d. and 16d. per lb. for his lint before he could show a profit if he employed solely hired labour. He, therefore, reduces his area, does most of the work himself and with the help of his family, and hires as little outside labour as he can. Even so it will clearly be necessary to grow a cotton that will command a considerable premium over American unless the price for the latter increases decidedly again. This should be possible, since experience during the last two seasons has proved that a cotton giving a full $1\frac{1}{8}$ inches to $1\frac{3}{16}$ inches staple can be produced over the greater part of the Queensland cotton belt. The crop mentioned above at Monal Creek Farm was Durango, and was good, sound-bodied cotton of this staple. Up to the present, however, the only seed available has been of mixed origin. During the present season this seed has shown signs of great deterioration, so that a good deal of it is now averaging ¾ inch to an inch in length only.

This year it is proposed to issue nothing but acclimatized Durango seed. Several pure seed community growing areas were organized and planted with this end in view last spring. Owing to the fact that three years ago all cotton received the same price on the Government guarantee, and that last year only was it found possible to grade the cotton, the difference in value of different cottons is not yet appreciated by the growers as a rule. The sooner the grower realizes that he cannot expect the same price from coarse ¾ inch cotton as for good heavy-bodied full $1\frac{1}{8}$ inches, the sooner he will set to work to demand better seed and improve his methods of cultivation. We have proved during the last two years that heavy yields of this class of cotton, both of Durango and Acala, can be produced. It appears also to be equally obvious that the Queensland grower cannot afford to grow the present inferior mixed and short stapled cotton. It is simply not an economic proposition.

Importance of Plant Breeding Work.

This all tends to emphasize the vital importance of plant breeding and selection work, and the successful establishment of the Callide Cotton Research Station in the heart of the main cotton belt is there-

fore a matter for great satisfaction. A good start has been made in breeding types suitable for this country, and an endeavour is being made to breed out types to suit the various parts of the State. Full $1\frac{1}{8}$ inches "bread and butter cotton" is aimed at, and certain points, such as the time of ripening, the size of the bolls, and similar details, are being carefully considered. Further than that, a small but keen and efficient staff is being collected and trained, which should at least ensure that continuity which is so essential in work of this description.

Cost of Picking.

The high charge for picking cotton must strike anybody who is cognizant with cotton-growing conditions in other countries, as a serious matter. Recent figures, published by the United States Bureau of Agricultural Economics, show that in the picking seasons of 1923 and 1924 the rate varies from \$0.60 to \$1 in the eastern belt to \$1 to \$1.50 per 100 lbs. of seed cotton in the western area where pickers were scarce and wages higher. The average rate worked out at between $\frac{1}{2}$d. and $\frac{3}{4}$d. a pound. In Africa and India, of course, picking rates are lower still. It seems evident, therefore, that these high picking charges must be placing Queensland at a serious disadvantage compared with other cotton-growing countries. The reason for this state of affairs is undoubtedly partly due to economic causes connected with the high cost of living, but is also caused by the lack of experienced pickers and to the way in which the crop is grown.

The question of skill in picking may be expected to right itself after a few years' experience, since it must be remembered that the crop is still only a new one in this country. The high rate demanded by pickers is caused by the fact that they are not able to pick large enough tallies to cover the recognized standard wage that is usually considered desirable—viz., from 12 to 15 shillings a day. About 80 lbs. a day is considered a reasonable tally, and this is probably quite hard work on some of the crops that are now being grown, where the yield is light and the picker consequently has to cover a lot of ground in order to fill his bag. One of the remedies, therefore, is to improve the yield per acre. The bigger the acre outturn the easier it will be to pick. Everything points to the fact, therefore, that growers will have to adopt more intensive methods of cultivation in the future. Already there are signs that the individual acreages under cotton will be considerably less in the future. Some of the large areas of badly cultivated and light yielding cotton have certainly

not paid to pick this season at 2d. a lb. If an examination is made of the acre yields and the size of the holdings, a marked correlation vill be found between high acre yield and the small size of the indivi-ual holding. It might be added that a corresponding improvement n the quality of the cotton will also be noticed.

Possibly arrangements can be made to enlist the assistance of the tone-fruit growers or other sections of the community as a regular practice during the cotton picking season. A really efficient cotton picking machine would, of course, do much to solve the difficulty. Unless this problem is solved, however, and cotton picking costs can be lowered considerably below 2d. a lb., it is bound to have a serious ffect on the future of the industry, because the crop cannot stand is rate.

The Effect of Pests and Diseases.

When the cotton boom was at its height about four years ago ich publicity was given to a statement that Queensland was prac-ally free from cotton pests. This, of course, has proved to be quite orrect, like a great many of the other wild statements made at that e. As a matter of fact, with the exception of the boll weevil, ueensland has nearly all the major cotton pests. The pink boll orm appeared about a year and a half ago, and has found a con-nial home in the Central District, where the practice of standing er or "cow-pruning" the cotton has given it a splendid oppor-nity of increasing its numbers and thoroughly establishing itself. e prompt measures taken by Government to disinfect all seed by at last year has checked the spread to the Southern areas, but there o doubt that it will be difficult to prevent the pest from spreading degrees over the whole belt. Already this year in certain areas r the coast north of Gladstone it has caused such damage as to der cotton-growing unprofitable. There is some doubt whether vill cause such serious damage further inland, as climatic conditions y keep it in check. In any case its control in those areas where it become established is in the hands of the farmers, and consists ourning up the débris of the old stalks each year by a certain date l of observing a close season during which no cotton shall be in l. Owing to the scattered nature of the holdings it is extremely icult, at present, to get all the growers to co-operate to this end. bably in the course of a few years this pest will have become so rious that the need for concerted action will be thrust upon the vers, or else they will decide to go out of cotton-growing in these icular areas. The same causes render the control of other insect

Decontrol of the Industry.

Last year a deputation, consisting of members of the British Australian Cotton Association and the Queensland Council of Agriculture, approached the Federal Government, with the request that the industry should be released from Government control and that instead of a system of guaranteed prices, a bounty of 1½d. a lb. on all seed cotton arriving at the gin should be substituted, irrespective of quality. A big principle is, of course, involved, and the cost of the bounty would amount to about £90,000 a year on a 10,000 bale crop. This, curiously enough, is about the same as the loss on last season's crop, which under the guarantee system is shared half and half by the Federal and State Governments. It is likely that the guaranteed system of advances will be continued until July 31, 1926, as originally promised, and that afterwards some form of decontrol will take place. There is no doubt, however, that some carefully worked out scheme will have to be developed to replace the present system, and that if the matter is not very carefully handled the confidence of the growers will be shaken. As it is there is already a feeling of uncertainty, and unless a definite statement regarding terms and prices can be made by Government very shortly, many growers will hesitate about preparing their land for the coming season's planting in October, and a serious decrease in acreage may result.

The Marketing of the Crop.

At present the crop is mostly consigned for sale to Liverpool, but there is an increasing desire to try and develop a manufacturing industry in this country. Tenders for the purchase and use of cotton in Australia are now called for, and for the present season 1,000 bales have been purchased by a spinning concern in Sydney, and about 100 bales of low grade cotton have been disposed of to certain firms for bedding and upholstery work. There is some talk of a tariff on imported cotton goods and also of developing the spinning industry, and there is no doubt that the trend of public opinion in Australia is towards developing their own cotton manufacturing industry, both with the view of saving sea freight on cotton exported and also of developing their home markets. These are matters for the future, however, and the present problem is, of course, to endeavour to ensure that enough cotton is grown each season to enable a manufacturing business to be continuously worked.

Conclusion.

My three years in Australia have been somewhat strenuous, but most interesting. Arriving as one did after the cotton boom had passed the peak of its enthusiasm, one had to settle down to a lot of spade work. It is always unpleasant to be compelled to expound certain stern facts. These may be wholesome and necessary, but are usually unpalatable to the public. My own personal relations with the actual grower and those of my staff have, with one or two exceptions, been invariably happy, and I have always met with the utmost hospitality and kindness when visiting them individually on their own farms. The way in which these growers are attempting to open up new country under very difficult conditions has to be seen to be thoroughly appreciated. The new settlers, their wives and families, have many hardships and discomforts to put up with, and, if bad seasons come along at the start, often have a difficult time. The way in which these difficulties are being faced, and the discomfort cheerfully borne, compels admiration. There is a small, but extremely vociferous, section of the community who have been and still are very much in evidence. They have set themselves up as the determined and destructive critics of the Government's cotton policy and have done a good deal of harm by confusing the grower, since they have little that is practical or constructive to suggest and their conclusions are not usually based on actual knowledge or real facts, and are therefore misleading. Their motives appear to be either personal or political, and it is doubtless a good thing for the future of cotton-growing in this State that they are comparatively few in number, and that most of them are not cotton growers.

I was cordially received by the Officers of the Local Agricultural Department, and my connection with them has been most happy. My relations with the two Ministers and Under-Secretaries, who have been in charge of the Queensland Department of Agriculture and Stock during my period of work in this State, have been most pleasant, and I wish to record my gratitude for the courteous and kindly attitude they have taken. The Director of Agriculture and his staff have always been only too willing to place their knowledge at my disposal; their intimate acquaintance with local conditions has been invaluable, and I have naturally availed myself of it to the fullest extent.

The need for experimental work and for improved seed was obvious from the first, as also the need for field officers, whose duty it would be to demonstrate certain facts that are essential to profitable cotton

cultivation. It is some satisfaction to be able to record, therefore, that it has been found possible to collect and train a small but efficient staff of field officers, and to advocate and see started a properly equipped and staffed Cotton Research Station. Plant breeding work is now being done on definite systematic lines, and a small staff of keen men has been trained in this important work who should be capable of carrying on the continuity of the work and indeed of elaborating it as the need arises. The coming season ought to see the whole area under a pure seed (Durango), and this in itself will be a great step forward, as although Durango may not eventually prove to be the best variety for the whole State, and will, of course, be replaced by better types as plant breeding becomes effective, yet it is undoubtedly by far the best seed as yet available in sufficient quantity. It is sincerely to be hoped, therefore, that the growers will be wise enough to avail themselves of this opportunity to place the industry on a better footing. Similarly, the grading and stapling of cotton has been brought into prominence, and a capable staff has been trained in the work. Above all, a good deal of the preliminary opposition has now been overcome, and the general public are beginning to appreciate the necessity for the classing of cotton on a rational basis.

It will be seen, therefore, that in many respects the cotton-growing industry is now on a much sounder foundation than it was when the boom started five years ago. At present there is the inevitable reaction after this boom. Economic conditions and the price of cotton will be the deciding factors and will determine whether the industry will steadily expand into an important industry, or whether it will gradually decline owing to the fact that the farmer will not be able to make the crop pay or may find it more profitable to devote his energies to other forms of agriculture. It seems probable, however, that cotton has come to stay as a crop that can be usefully introduced into the rotation of the small mixed farm over large areas in Queensland, and it will undoubtedly be a big factor in settling the large areas of land that await development there.

A DISEASE OF QUEENSLAND COTTON SEED

BY

C. A. PRATT, M.A., Ph.D., D.I.C.

Samples of Queensland cotton seed of the season 1923-24 were received during October, 1924, with the report from Mr. Ballard, cotton entomologist to the Corporation, that about 30 per cent. of the seeds "either failed to germinate, or on germination taking place, the radicle came through in a diseased condition. The symptom was usually a brown discoloured patch on the first root, which later turned soft and slimy. In about 77 per cent. of those seeds which failed to germinate the contents were a brown slimy mass." The failure to germinate of the remaining 23 per cent. is attributed to "drought effect"—*i.e.*, absence of embryos or shrivelled embryos in the seeds. Examination of seeds before germination revealed the fact that some of "the seeds showed a yellow stain on the embryo, sometimes at the tip of the radicle, sometimes on the cotyledons. In some cases the radicle was shrivelled away entirely."

Confirmation of these observations has been obtained in the present investigation. Externally the seeds showed no appearance of disease. Several hundred of the seeds were cut open and examined. About 25 per cent. showed brown patches in the embryo, most often in the radicle. Some difficulty was experienced in demonstrating the presence of fungal hyphæ in diseased seeds, either dry or those which had been preserved in spirit, probably owing to the abundance of food substances in the cells.

Germination Experiments.

Seeds were germinated (*a*) in soil in a greenhouse at Chelsea Physic Garden, and (*b*) in sterilized sand in an incubator at 30° C. The seeds were examined after seven and four days respectively.

No. of Seeds.	*Failed to Germinate.*	*Percentage Failure.*
(*a*) 66	20	30·3
(*b*) 114	32	28·7

Of those seeds which failed to germinate, nearly all were diseased; only two and three respectively were not.

The insides of some of the seeds were examined under the microscope. In each case the embryo, which had become yellowish brown and slimy, showed abundant fungal hyphæ.

Isolation of Organism.

Attempts to isolate the organism causing the disease were made as follows:

(1) From seeds which failed to germinate in soil at Chelsea (six seeds).

(2) From seeds which failed to germinate in sand (twelve seeds).

(3) From dry ungerminated seeds showing brown patches (six seeds).

These seeds were cut with a sterile knife on a sterile porcelain tile, and plates inoculated with small portions from the interior of each seed. The following media were used: Brown's synthetic, Brown's + lactic acid and plain agar.

The plates were examined after four days. Of the twenty-four plates, two were discarded, since they were contaminated; while twenty-two showed *Fusarium* with abundant microconidia and macroconidia, pointed and three or four septate. When no lactic acid had been added, bacteria, principally a golden yellow coccus, always appeared with the fungus (nine times).

The *Fusarium* and three bacteria have been isolated by the usual methods.

The *Fusarium* isolated is characterized by its very abundant microconidia which are developed in chains. The septate macroconidia are very sparingly developed and are often absent. It has been found that macroconidia are produced to any extent only in those cultures which are contaminated with bacteria. Cultures were sent to Dr. H. W. Wollenweber, and he identified the fungus as *Fusarium moniliforme* Sheldon, stating that it belongs to the new section *Liseola Wr., Reinking, Sherbak, Bailey and Johann.*

The bacteria have been numbered A, B and C. A is a coccus, bright golden yellow and moist in culture, B is a long rod-shaped organism, creamy white and viscous, and C consists of short rods, cream-coloured but not viscous.

From the results of the experiments described below, the conclusion has been reached that the disease of the cotton seeds is due to the action of the *Fusarium*, and that the bacteria, which have no effect, constitute the usual contamination of the hairy seed coat.

Correlation of Presence of "Fusarium" with Diseased Condition of Cotton Seeds.

Twenty-two of the Queensland cotton seeds which had been washed in a dilute solution of formalin were cut under as sterile conditions as possible and each put on to a potato mush agar slope. When the cultures were examined after an interval of seven days, all showed bacteria, and six showed the microconidial stage of the *Fusarium* as well. Thus the *Fusarium* appeared in 37·5 per cent. of the seeds, a proportion which compares well with the number which failed to germinate (30·3 per cent.) The invariable appearance of the bacteria was taken to show that the attempt to sterilize the seed coats was unsuccessful. As a matter of fact, sterilization by this method is rendered impracticable by the hairy nature of the seed, which makes complete damping of the seed coat by the solution very difficult.

It has also been possible to correlate the brown patches in the embryo with the presence of *Fusarium* and with failure to germinate. For this purpose a number of the seeds were soaked in distilled water and then skinned. The embryos were divided into two lots: (i.) apparently healthy, and (ii.) those with brown patches. These embryos were put to germinate at 30° C. in sterile Petri dishes lined with moist filter paper.

No. of Seeds Tested.	*Germination in Twenty-four Hours.*		*Examination after Five Days.*
	+	−	
(i.) 43 ..	43	0	All without *Fusarium*.
(ii.) 17 ..	5	12	All with *Fusarium*, and radicles of five germinated brown and slimy.

+ = germinated. − = failed to germinate.

Inoculations of Cotton Seeds.

A number of inoculation experiments have been carried out in which the organisms isolated were introduced into ripe seeds. The material available for this purpose consisted of Allen's Long Staple seeds from Northern Nigeria, and Sakelarides seed from the Sudan.

Experiment I.—In this experiment *Fusarium* and bacterium A were put on to the outsides of the seeds, and it was found that, although percentage germination was not reduced, yet, in the case of *Fusarium*, the radicles were rotted soon after their appearance.

The seeds were placed in three small flasks with sterile water. One flask was left for a control and the others inoculated with the *Fusarium* and bacterium A, respectively, and the seeds left to soak overnight. All the seeds were then removed from the flasks and put to germinate.

Treatment.	*No of Seeds.*	*Germination in Three Days.*		*Remarks.*
		+	–	
Control ..	64	35	29	Seedlings with white roots, others healthy inside.
Fusarium ..	46	38	8	All roots brown, four entirely slimy tissues full of hyphæ.
Bacterium A.	49	27	22	Seedlings with white roots, others healthy inside.

When kept for longer than five days or so all the seedlings rotted, controls and inoculated ones alike, the rot being due chiefly to an evil smelling bacterium (numbered D) derived from some external source.

Experiment II.—The roots of the healthy-looking germinated seeds from Experiment I. were inoculated, some with *Fusarium* and some with bacterium A, and then left for three days. Of the seedlings inoculated with the bacterium A, eight were unaffected, though the patch of bacteria could be seen dried up on each root, while three were partially rotted with the bacterium D, which had appeared as an outside contamination in the previous experiment. All the seedlings (nine) infected with the *Fusarium* were more or less rotted; abundant hyphæ were present in the root tissues and the fungus was sporing on the outsides of the roots.

Experiments III.—VII.—In the following experiments inoculation was effected by stabbing each seed with a needle. The seeds were soaked for several hours in sterile water, and the *Fusarium* or bacteria pricked into each seed. The seeds were left to germinate at 30° C. on moist filter paper in Petri dishes.

It will be seen by reference to the table in which experiments III., IV., V., VI., and VII. are summarized, that the bacteria isolated (A, B, C) are incapable of producing the disease in the cotton seeds. Though germination may not always be affected by the *Fusarium*, the seedlings are invariably rotted.

On cutting open the seeds inoculated with *Fusarium*—this was done particularly in the case of the Sudan seed—it was found that in those seeds which had not germinated large areas were brown and infested with fungal hyphæ; the root was always affected, and in some cases the entire embryo. The germinated seeds had small

nfected regions some distance from the roots. The brown region exactly resembled that found in a diseased seed.

It appears, then, that failure to germinate is the result of the presence of the *Fusarium* in the radicle of the embryo, a condition more likely to obtain in the diseased seeds where the fungus has been present for some time than in the inoculated seeds where the fungus has had only a few days to act.

SUMMARY OF EXPERIMENTS III—VII.

Expt.	*Treatment.*	*No. of Seeds.*	*Germination in Three Days.*		*Remarks.*
	Nigerian Seed.		+	–	
III.	Control untouched	25	25	0	Good.
	Control stabbed ..	25	25	0	Good.
	Fusarium	24	1	23	Brown rot inside root, slimy.
IV.	Control untouched	23	15	8	Good.
	Control stabbed ..	74	41	33	Slight discoloration round stab, three roots poor, others good.
	Fusarium	27	7	20	Brown rot, 2 roots slimy, others poor.
	Bacterium A ..	29	19	10	No rot, roots good.
	Bacterium C ..	19	11	8	Slight discoloration, roots good.
V.	Control	53	35	18	No rot, three without embryos.
	Bacterium B ..	67	48	19	No rot, four without embryos.
	Sudan Seed.				
VI.	Control	16	11	5	Good.
	Bacterium A ..	23	23	0	One discoloured.
	Fusarium	30	24	6	Brown rot and hyphæ inside.
VII.	Control	30	25	5	Some discoloured round stab.
	Bacterium A ..	32	27	5	A few discoloured round stab.
	Fusarium	37	14	23	Brown rot and hyphæ.
	Bacterium B ..	29	21	8	As control.

Inoculation Experiments with Cotton Plants.

A number of cotton plants in fruit were placed at my disposal by the Director of the Royal Gardens, Kew. These plants were transferred to a small greenhouse attached to the Jodrell Laboratory. The greenhouse was kept at a temperature of 65° F. and was very damp. The plants, however, soon flagged, and their bolls became

infected with "anthracnose" due to *Colletotrichum* before the end of the experiment.

The cotton bolls were inoculated with the *Fusarium* and with bacterium B. The inoculations were carried out with sterile glass tubes which had been drawn out to fine points. Each boll was inoculated in two places. The controls were stabbed with a glass needle. A number of bolls were left untouched. One plant bearing several bolls was kept in a separate house.

The bolls were cut off the plants after ten days and examined. All the bolls were more or less affected by the attacks of *Colletotrichum*, including those from the other house. Each boll was wrapped up separately and kept for a week in a dry place before it was examined in detail and the seeds put to germinate.

Such evidence as has been obtained supports the conclusion, arrived at from the results obtained from the seed inoculation experiments, that the *Fusarium* is the causative organism, for only where *Fusarium* has been introduced into the bolls did the seeds show any appearance of disease. These seeds were brown inside.

Attempts to germinate the seeds collected from the inoculated bolls were but slightly successful, owing in all probability to the fact that the seeds did not properly ripen as the result of unfavourable conditions of light, temperature, and moisture.

The fungus is, then, capable of growing into the seeds once it has been able to get through the boll wall, probably in nature by means of insect punctures. Moreover, the *Fusarium* produces in the seeds symptoms of disease similar to those found in the diseased Queensland seeds.

Discussion.

As far as the present writer is aware *Fusarium moniliforme* has not previously been reported to occur in Australia, and, moreover, this is the first time that this species has been described on the cotton plant. As a parasite of corn in the southern states of U. S. America it is widespread, causing root, stalk, and ear rots as well as affecting the seed corn. An account of *Fusarium moniliforme* is given by Wineland (4) who provides a good bibliography.

More nearly relevant to the present investigation is the work of Valleau (2) on seed corn infection with *Fusarium moniliforme*, and that of Manns and Adams (1) on parasitic fungi internal of seed corn.

Valleau (2), working in Kentucky, germinated apparently healthy seeds selected from diseased ears at various distances from obviously

infected seeds. A high percentage of these seeds gave rise to diseased seedlings, the root tips of which were brown and rotting. He found, also, that the diseased condition of the seeds might not appear in the usual time given for germination tests (seven or eight days), but if they were grown in sand for a longer period of time the seedlings frequently developed discolorations of the seed coats and often a severe rotting of the roots and stems. Invariably *Fusarium moniliforme* was isolated from the rotted roots.

It will be remembered that rotting of the roots was found to be a constant symptom of the presence of *Fusarium moniliforme* in cotton seedlings.

It seems clear from Valleau's work that this fungus is capable of causing stalk and root rot of the mature corn plant. How far it is capable of causing disease of the mature cotton plant it would be interesting to know: no evidence on this point has, as yet, appeared.

Manns and Adams (1) found that *Fusarium moniliforme* was one of the four parasites consistently present in the seed corn which they examined from seventeen states of U.S.A. and that the fungi caused inhibition of germination in varying degrees. In discussing the *Fusarium*, they state that the embryo in the cracked kernels is frequently killed by the fungus, and, in those cases where germination of the seeds has taken place, strong seedlings are seldom developed.

There is, then, a very close resemblance between the effects of the presence of *Fusarium moniliforme* in the seeds of maize, as described, and those of the same fungus in cotton seed from Queensland.

Manns and Adams (1) state that, as indeed would be expected, seed disinfection of the corn did not prove successful owing to the manner of internal infection. Valleau (3) also found that various methods of seed treatment were ineffective in controlling corn root rot. Similarly, it has been found in the present investigation that disinfection of the outside of the seed did not destroy the fungus inside the cotton seed.

It may be useful here to refer to the suggestions advanced as to the mode of entry of the fungus into the corn seed. Valleau (3) is of the opinion that infection takes place before the early dough stage and probably occurs through the silks as the result of the infection of the exposed silk mass with *Fusarium moniliforme*, presumably by means of wind borne spores. Manns and Adams (1) appear to favour the suggestion that infection of the seed corn is indirect, occurring by means of systemic, stalk, or shank infection. "When," they say, "the ear is broken in half and a discoloration of the vascular system is observed, it is very good evidence of an infected ear." Such

infection does not necessarily follow from the planting of infected seed, but may also occur because of soil infestation.

How far these suggestions are helpful in dealing with the problem in the case of the cotton seed remains to be determined experimentally. Attempts are now being made to find out whether infection of the stigmas in the flower results in infection of the seed. It is hoped, also, to investigate the possibility of infection through the plant—*i.e.*, from root infection due to infected soil. Some clue to this aspect of the problem might have been afforded by particulars as to the condition of the cotton plants from which the diseased seed was gathered, but these are not available.

Mr. Ballard, in the report sent with the sample of diseased seeds, suggests the probability of insect agency. To quote from him: "The insect most prevalent all through the year and the most capable of damage is the big Pentatomid Bug, *Tectacoris banksii*, generally known as the Chinese Bug or Harlequin Bug. It is significant that this year (1923-24) has been marked by a big increase of this insect in the cotton fields, and it is not, from its habits or colouring, an insect that is likely to be overlooked. I have had reports from all parts saying that this bug has been seen this year for the first time, and, from personal experience, I know how heavily the fields are infested with it. Observation in the fields has shown me that this insect feeds on green bolls and on the seeds after the boll has opened. In many cases punctures have been traced through the boll wall, which could only have been made by a large insect like *Tectacoris* provided with a powerful proboscis."

Now, such inoculations as have been effected in the present investigation tend to support the theory of insect puncture. In these experiments the fungus was introduced into green bolls by means of fine glass needles. However, the two other possibilities (the stigma and through the plant from the soil) remain to be explored, so that the case for the insect is by no means proven as yet.

Summary.

1. Diseased cotton seed from Queensland has been investigated. About 80 per cent. of the seeds fail to germinate; of these seeds nearly all are diseased—*i.e.*, the embryo becomes brown and soft. Examination of the dry seeds shows that there are brown patches in about 25 per cent. of the embryos.

2. Of the seeds which fail to germinate, all give rise to *Fusarium*. Fungal hyphæ are easily seen in the rotten tissues.

3. *Fusarium moniliforme*, producing very abundant microconidia in chains, and three bacteria, have been isolated from the diseased seeds.

4. When dry seeds are cut and plated out, *Fusarium moniliforme* is obtained in a ratio much the same as the ratio of failure to germinate. Bacteria, probably carried in from the outside of the seeds, are obtained in all cases.

5. All embryos with brown patches give rise to the *Fusarium*.

6. When *Fusarium moniliforme* is put on to healthy seed, germination is not reduced, but the seedlings are attacked.

7. Healthy seedlings are attacked by *Fusarium* and not by the bacteria.

8. When *Fusarium moniliforme* and bacteria are stabbed into the seed, the bacteria have no effect, while the *Fusarium* produces a brown rot resembling that found in the diseased Queensland seed. Germination is affected only when the *Fusarium* has reached the radicle. Seedlings are always rotted.

9. The results of inoculations of cotton bolls on the plants indicate that the *Fusarium* is capable of growing through the lint and into the seeds; moreover, the seeds thus infected are brown inside and do not germinate.

10. The bearing of the work on stalk, root, and ear rot of corn in U.S.A. due to *Fusarium moniliforme* on the cotton seed disease problem is discussed, and the possible paths of infection considered.

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THE PRINCIPLES AND PRACTICE OF YIELD TRIALS

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SECTION I.—THE DIFFICULTIES OF YIELD TRIALS AND THE GENERAL PRINCIPLES

Alice soon came to the conclusion that it was a very difficult game indeed.—
ALICE IN WONDERLAND.

INTRODUCTORY NOTE.

THE problem considered in the present paper is that of testing the comparative yields, per unit area of the ground, of a number of different varieties of the same plant. From the general standpoint, it is of no consequence what part of the plant may be of economic importance—seed, stem, leaf, sap, root, or tuber—for the difficulties to be met and the principles applied to meet them are the same. The problem is one to which much attention has been devoted of recent years: we have made no attempt in this article to add anything novel, except, perhaps, on one point—the difficulties due to varying weather—but have simply endeavoured to give an elementary exposition of the difficulties, and of the resulting principles on which trials should be conducted. In the present section the general statistical principles are developed; in Section II. consideration will be given to the more practical details of arrangement.

SECTION I.

1. The first question that may be asked by anyone of little practical experience is, What *is* the difficulty? If you want to know what are the comparative yields of varieties A and B, why don't you just grow, say, half an acre of each and find out? The answer is that the result of such a test is of no value whatever. The order of magnitude of the difference to be expected is very likely no more than 10 per

cent. or so, and two plots of the *same* variety may show a difference as large as this owing to the more or less inevitable differences between the two plots as regards character of the soil, drainage, prevalence of weeds, and so forth.

2. Few people still seem fully to realize how large is the variation in yield over different portions of the same—apparently fairly uniform —field. In 1910 Hall and Mercer* selected a "very uniform area" of one acre in a wheat field at Rothamsted, in which the crop "promised to be a fair crop for the season and was generally standing up well." They divided up this acre into little plots of $\frac{1}{500}$ acre (9·68 square yards), and weighed separately the grain from each plot: the weights are given in the original paper to the nearest hundredth of a pound. The results are summarized in Table I., column 2, by grouping the weights to the nearest tenth of a pound. It will be seen that the range of variation is enormous: the bulk of the yields lie round about the mean (3·945 lbs.), but tail away to nearly as low as 2·7 lbs. and rise nearly as high as 5·2 lbs. The highest yields are 90 per cent. or more in excess of the lowest. The standard deviation is 0·459 lb. or 11·6 per cent. of the mean.

3. "But," our imaginary questioner may reply, "I did not suggest taking trial plots so absurdly small as $\frac{1}{500}$ of an acre. I suggested half-acre plots. A half-acre would contain 250 of your little plots, and surely the average so given would be reasonably trustworthy?" If he had dabbled a little in the theory of sampling, he might even add that the standard error of the mean yield determined from half an acre would be only $\frac{0\cdot459}{\sqrt{250}}$, or 0·029 lb., and quite small enough for his purpose. Unfortunately, the whole of this argument is fallacious, and the reason why it is fallacious brings out the special difficulty of yield trials and at the same time suggests the method of meeting it.

4. *Theory of Sampling for the Mean.*—Before illustrating the point on the data, we must first remind† the reader of the theory of fluctuations of sampling in the mean. Let X denote the yield from

* W. B. Mercer and A. D. Hall, "The Experimental Error of Field Trials," *Journ. Agr. Science*, iv., 1911, p. 107. The yield of straw is given as well as the yield of grain of the wheat, and a similar analysis is given of an acre of mangolds.

† We cannot avoid assuming that the reader has some familiarity with statistical method, though we have endeavoured to give all necessary formulæ and explanations. Those who have not much experience should refer to Yule's "Introduction to the Theory of Statistics" (Charles Griffin and Co., 12s. 6d.), especially Chapters VI.-VIII., IX.-XI. (Correlation), XVII., §§ 10-13 (Standard Error of the Mean).

TABLE I.—YIELD OF GRAIN IN POUNDS FROM PLOTS OF $\frac{1}{500}$TH ACRE IN A WHEAT FIELD (COL. 2), AND MEAN YIELD IN RANDOM GROUPS OF TEN PLOTS (COL. 3) AND STRIPS OF TEN (COL. 4)

1.	2	3	4
	Number of Plots with Yield between Limits Shown on the Left		
Yield of Grain in Pounds per $\frac{1}{500}$th of an Acre	*Single Plots.*	*Random Groups of Ten*	*Strips of Ten*
2·7 but less than 2·8	2	—	—
2·8 „ „ 2·9	2	—	—
2·9 „ „ 3·0	3	—	—
3·0 „ „ 3·1	12	—	—
3·1 „ „ 3·2	10	—	—
3·2 „ „ 3·3	10	—	1
3·3 „ „ 3·4	18	—	—
3·4 „ „ 3·5	29	—	1
3·5 „ „ 3·6	26	—	3
3·6 „ „ 3·7	37	3	7
3·7 „ „ 3·8	41	3	5
3·8 „ „ 3·9	34	12	5
3·9 „ „ 4·0	46	15	9
4·0 „ „ 4·1	42	11	6
4·1 „ „ 4·2	28	4	3
4·2 „ „ 4·3	41	1	3
4·3 „ „ 4·4	31	1	2
4·4 „ „ 4·5	28	—	1
4·5 „ „ 4·6	22	—	3
4·6 „ „ 4·7	13	—	1
4·7 „ „ 4·8	7	—	—
4·8 „ „ 4·9	3	—	—
4·9 „ „ 5·0	5	—	—
5·0 „ „ 5·1	3	—	—
5·1 „ „ 5·2	4	—	—
Total	500	50	50

any one of the little plots, let N be the number of them, and let M be the mean yield, so that—

$$M=\frac{S(X)}{N}, \qquad \ldots\ldots\ldots\ldots\ldots\ldots(1)$$

where S(X) denotes the sum of all the X's—*i.e.*, the total of the yields from all the 500 little plots. Let x denote the deviation of the yield on any plot from the mean yield M—*i.e.*, $x=X-M$—and let

$$\sigma^2=\frac{S(x^2)}{N} \qquad \ldots\ldots\ldots\ldots\ldots\ldots(2)$$

Then σ is the *standard deviation* of the yields, and is a measure of their dispersion round the mean yield. The square of the standard deviation may be briefly termed the *variance* (R. A. Fisher).

Now suppose that we have recorded the yields from a *very large number* of little plots of $\frac{1}{100}$ of an acre, that we record these yields on counters, throw them into a bag and take out n of the counters at random. We can then form the mean, say Z, of this sample of n plots—

$$Z=\frac{1}{n}(X_1+X_2+\ .\ .\ .\ +X_n)\ \ldots\ldots\ldots\ldots(3)$$

If we keep on taking out such samples of n values at a time, evidently the mean of the value of Z tends towards M, the mean of the whole record. Further, since there is no essential difference between the first, second, . . . nth counters in the sample, the means of X_1, X_2, . . . X_n must also each tend towards M. Hence if z is the deviation of Z from M we may also write—

$$z=\frac{1}{n}(x_1+x_2+\ .\ .\ .\ +x_n)\ \ldots\ldots\ldots\ldots(4)$$

—where x_1, x_2, etc., are the deviations of X_1, X_2, etc., from M. To find the standard deviation of Z, square both sides of (4) and sum, and we have—

$$S(z^2)=\frac{1}{n^2}\left\{\begin{array}{l}S(x_1^2)+S(x_2^2)+\ .\ .\ .\ +S(x_n^2)\\ +2S(x_1\,x_2)+2S(x_1\,x_3)+\ .\ .\ .\\ +2S(x_2\,x_3)+2S(x_2\,x_4)+\ .\ .\ .\end{array}\right\}\ \ldots\ldots\ldots\ldots(5)$$

On the right-hand side we have first the series of sums of squares, $S(x_1^2)$, $S(x_2^2)$, etc. If there are m samples, each of these sums will tend to the value $m\sigma^2$. Next we have the long series of sums of products of deviations, $S(x_1\,x_2)$, and so on. But, if we carried out the process of sampling as supposed, all these would tend to vanish; for a positive deviation x_1 would tend to be equally frequently associated with a positive and with a negative deviation x_2, and the products would therefore tend to cancel out: and so on with all the other product-sums. Therefore *in these circumstances* we have simply, if ϵ_z is the standard deviation of Z—

$$\epsilon_z^2=\frac{1}{n^2}(n\sigma^2)=\frac{\sigma^2}{n}\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots(6)$$

The mean of a sample may be regarded as differing by an "error" (of sampling) from the "true" mean M in the record as a whole: ϵ^2 may be regarded as a measure of such errors, and it is usually termed

the "*standard error*" of the mean—hence our use of ϵ rather than σ as the symbol. Note that this, the usual simple formula, applies if, but only if, the process of sampling is so carried out that the product-sums, $S(x_1 x_2)$, and so on in (5), all tend to be zero.

If the experiment is not carried out in such a way as to make all the product-sums zero, the equation (6) will not hold good, but we can still express the result briefly in symbols. The correlation coefficient between any two variables X and Y is defined by—

$$r_{xy} = \frac{S(x\,y)}{N\sigma_x\,\sigma_y} \quad \ldots\ldots\ldots\ldots\ldots\ldots (7)$$

—where x and y are the deviations of the two variables from their respective means, σ_x and σ_y are the standard deviations, and N is the number of observations. Hence the product-sums in (5) may be written, m being the number of samples, $mr_{12}\,\sigma^2$, $mr_{13}\,\sigma^2$, where r_{12} is the correlation between x_1 and x_2, r_{13} the correlation between x_1 and x_3, etc., and so on. But the number of product-sums is the number of pairs of n things taken two together—that is, $\frac{n\,(n-1)}{2}$. Hence if r be the arithmetic mean of all the correlations r_{12}, r_{13}, etc. we have—

$$\epsilon_s^2 = \frac{\sigma^2}{n}\,(1 + \overline{n-1}\,r) \quad \ldots\ldots\ldots\ldots\ldots (8)$$

This is the general form of the equation (6).

5. *Standard Error of Difference between Two Means.*—Finally, to obtain another formula or two that we shall require, remember that if X and Y are two *uncorrelated* variables, and x and y the deviations from their respective means—

$$S\,(x-y)^2 = S(x^2) + S(y^2),$$

—since the product-sum vanishes. Hence if σ_1 and σ_2 are the standard deviations of X and Y, and σ_{12} the standard deviation of X − Y

$$\sigma_{12}^2 = \sigma_1^2 + \sigma_2^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots (9)$$

—*i.e.*, the *variances* add. Now suppose that in our experiment in sampling we take out samples *in pairs*, work out the mean of each sample of the pair, and then the difference of the means—*e.g.*, the mean of the first sample less the mean of the second sample. In the long run the average of this difference must tend to be zero obviously; sometimes the mean of the first sample and sometimes the mean of the second being the greater. But what will be its standard deviation?

Let ϵ_1 be the standard deviation (standard error) of the first mean, ϵ_2 of the second, and let ϵ_{12} be the standard error of their difference; then by (6)—

$$\epsilon_1^2=\frac{\sigma^2}{n} \qquad \epsilon_2^2=\frac{\sigma^2}{n}.$$

Therefore by (9)—

$$\epsilon_{12}^2=\epsilon_1^2+\epsilon_2^2=\frac{2\sigma^2}{n} \quad \ldots\ldots\ldots\ldots\ldots(10)$$

The general form of (10) is fairly evident. If we draw one sample of n_1 observations from one record in which the standard deviation is σ_1, and a second sample of n_2 observations from another record in which the standard deviation is σ_2, the standard error of the difference between the two means is given by—

$$\epsilon_{12}^2=\frac{\sigma_1^2}{n_1}+\frac{\sigma_2^2}{n_2} \quad \ldots\ldots\ldots\ldots\ldots(11)$$

6. *Experiment in Sampling on Hall and Mercer's Data.*—An experiment in sampling on much the lines suggested at the beginning of § 4 was carried out on Hall and Mercer's data. A copy of the plan of the field in the original memoir was made on squared paper, a square inch representing each little plot, and the yields entered on this plan, which was then cut up with scissors so as to give 500 tickets with the yields entered on them. These tickets were then mixed up in a bowl, drawn out in sets of ten, and the mean yield (per $\frac{1}{500}$ acre) calculated for each set. The frequency distribution for the fifty sets of ten is shown in column 3 of Table I.: its standard deviation is 0·144 lb. The formula (6) gives—

$$\frac{0{\cdot}459}{\sqrt{10}}=\frac{0{\cdot}459}{3{\cdot}162}=0{\cdot}145$$

—which is a very much closer agreement than we have any right to expect: the experiment was rather a lucky one. The standard deviation is here 3·7 per cent. of the mean.

7. But what happens if we take, not random sets of ten plots, but solid blocks or strips? This is the important practical question. To illustrate this, we worked out the mean yield (per $\frac{1}{500}$ acre) for strips made up of ten plots, in a vertical line on the original plan. The results for these strips are shown in column 4 of Table I. Evidently we have an entirely different state of affairs: the scatter is very much greater than for the random sets of ten. Actually the standard deviation is 0·306 lb. (7·8 per cent. of the mean) or more than twice as much as before. That is, the actual standard deviation of

the mean yields from the ten-plot strips is greater than the value of ϵ_s calculated from (6), although (6) was verified by the means of random groups of ten plots.

8. The reason for this result is fairly evident on very little consideration. Since the actual value of the standard deviation is greater than the value given by (6), the product-sums in (5), and therefore the average correlation r in (8), must be positive. Instead of positive x_1's being on the whole associated equally frequently with positive and with negative x_2's, positive x_1's must be on the whole associated with positive x_2's and negative x_1's with negative x_2's, and so on. That is to say, if any one plot forming part of a strip has a yield above the average of the whole acre, the other plots in the strip must tend to show yields above the average also: the yield on any one plot of a strip is positively correlated with the yield on any other plot of the same strip. The average value of this correlation can be readily calculated from (8). Putting $n=10$, $\epsilon_s=0{\cdot}306$, $\sigma=0{\cdot}459$, it gives—

$$r=0{\cdot}37.$$

In whatever way we build up blocks of ten plots—*e.g.*, strips of ten in a line across the field instead of down it, or rectangles of two across by five down, or rectangles of five across by two down, we would get a result of precisely the same kind, though of course differing more or less in arithmetical value. And the larger the blocks or strips were made the greater would be the divergence of the standard deviation ϵ_s from that given by (6). The following are the results given by Hall and Mercer for blocks of different sizes: they do not state how their blocks were formed, and their standard deviation for blocks of ten plots is rather lower than ours.

TABLE II.—HALL AND MERCER'S RESULTS FOR THE STANDARD DEVIATION OF THE YIELD (AS A PERCENTAGE OF THE MEAN YIELD) ON BLOCKS OF PLOTS IN A WHEAT FIELD.

1.	2.	3.	4.
Number of Plots in Block	*Area (Acres).*	*S. d. of Yield as per cent. of Mean.*	*Value Given by (6).*
1	$\frac{1}{500}$	11·6	11·6
2	$\frac{1}{250}$	10·0	8·2
4	$\frac{1}{125}$	8·9	5·8
10	$\frac{1}{50}$	6·3	3·7
10	$\frac{1}{50}$	7·8	3·7
20	$\frac{1}{25}$	5·7	2·6
50	$\frac{1}{10}$	5·1	1·6

If random aggregates of plots, instead of solid blocks, had been formed as in our experiment, the standard deviations would have been in more or less close agreement with those in column 4: 11·6, $\frac{11\cdot 6}{\sqrt{2}}$, $\frac{11\cdot 6}{\sqrt{4}}$, etc. Actually the values found were those in column 3, and these show greater and greater proportionate divergence from the figures of column 4. The larger blocks show, indeed, very little improvement, and suggest that no further increase of size would bring the standard deviation much below 5 per cent. of the mean. Trials with other crops give very similar figures, if they are rendered comparable with each other by expressing the standard deviation in the same way as a percentage of the mean: a collection of different crops gave 4·9 per cent. for blocks of half an acre, and this confirms the suggestion that there is little or no appreciable advantage in further increasing the size of the block: the standard error of the mean yield from a block of plots totalling half an acre cannot be taken as appreciably less than the standard error of the mean yield from a block totalling $\frac{1}{10}$ of an acre. Our imaginary objector who wanted simply to grow trial plots of half an acre of each of his varieties would have been quite wrong in assuming that the ordinary formula applied and that the standard error would be relatively small. He would be doubly wrong as a matter of practice, because not only would he be wrong in his assumption but, having grown only a single plot of each of his varieties, he would have no means of checking his assumption—*i.e.*, of calculating the standard error of his own data.

9. The preceding work has then shown that (1) the ordinary formula for the standard error of a mean cannot be applied to the mean yield of a block of small plots, because (2) the block does not form a random sample, the yields on closely adjacent plots in the larger area from which the block is taken tending to be positively correlated—*i.e.*, both high or both low. The result is obviously what might have been expected, for the soil of a field does not vary at random from point to point, but continuously, in patches or streaks; weeds grow in colonies; a choked drain affects a number of contiguous plots, and so forth. It is, therefore, no use to endeavour to reduce the standard error by taking large plots of each variety to be tested, and the question is how we are going to reduce it. The answer is suggested by the source of the difficulty.

10. "Small contiguous or closely adjacent plots tend to resemble each other." Very good: this is just what we want for getting a fair comparison between two varieties—we *want* the plots on which they are grown to be as like each other as they can possibly be. Keep

the plots small, therefore, and as closely adjacent as they can be without interfering with one another. Consider the differences only between such comparative adjacent plots, *and reduce the standard error by increasing the number of pairs of adjacent and comparable plots.* This is the general principle of all the methods which have been worked out by Dr. E. S. Beaven, of Warminster, and the theory of which has been mainly developed by the writer who has, unfortunately, to publish under the pseudonym of "Student."* The size of plot to be chosen, the shape of plot, and the general arrangement are matters of practice, which depend on the nature of the crop, the amount of seed available, and so forth, and these practical questions will be dealt with in detail in the second section of the paper. For the early stages of variety trials with cereals, when the amount of seed available is small, the usual arrangement adopted is a "chessboard" of very small square plots, the utilized area of each of which is no more than one square yard. A strip of these, perhaps five plots wide, under a cage of wire netting to protect the crop from birds and rabbits, will form the experimental area. Usually it is desired to test more than two varieties at once: suppose there are eight. Then the simplest arrangement is to sow them in order down the strip of plots, thus—

1	2	3	4	5
6	7	8	1	2
3	4	5	6	7
8	1	2	3	4
5	6	7	8	1
2	3	4	5	6
7	8			

—and so on, but other arrangements may be adopted (*Cf.* Section II.).

11. *Arithmetical Example.*—In one such trial there were eighteen plots given to each variety, and columns 2 and 3 of Table III. show the yield of grain (actually weight of ears) in grammes from each of the plots for two of the varieties of barley under test, to which we will for the moment confine our attention. The plots are simply taken in order as they occur down the strip, for each variety, the first plot of variety X being taken with the first of variety Y, the second of X with the second of Y, and so on. These may not be in all cases the most closely adjacent pairs, but a definite rule must be adopted. The means are shown in the table: the mean for X is 314 grammes

* *Cf.* his Appendix to Hall and Mercer's paper in *Journ. Agr. Science*, iv., and a further paper in *Biometrika*, xv., 1923, p. 271, "On Testing Varieties of Cereals."

TABLE III.—YIELDS (IN GRAMMES) OF GRAIN (X and Y) FOR TWO VARIETIES OF BARLEY FROM PLOTS OF 1 SQUARE YARD EACH SOWN WITH A DEFINITE NUMBER OF SEEDS. CALCULATION OF S. D OF DIFFERENCE AND CORRELATION BETWEEN YIELDS OF ADJACENT PLOTS.

1.	2.	3.	4.	5.	6.	7.	8.	9	10.	11.
	X.	Y.	x.	y.	$y-x$	$(y-x)^2$.	x^2.	y^2	xy. +	xy. −
1	368	410	+ 54	+ 65	+ 11	121	2,916	4,225	3,510	—
2	355	447	+ 41	+102	+ 61	3,721	1,681	10,404	4,182	—
3	371	393	+ 57	+ 48	− 9	81	3,249	2,304	2,736	—
4	320	350	+ 6	+ 5	− 1	1	36	25	30	—
5	357	408	+ 43	+ 63	+ 20	400	1,849	3,969	2,709	—
6	367	385	+ 53	+ 40	− 13	169	2,809	1,600	2,120	—
7	348	380	+ 34	+ 35	+ 1	1	1,156	1,225	1,190	—
8	315	383	+ 1	+ 38	+ 37	1,369	1	1,444	38	—
9	293	350	− 21	+ 5	+ 26	676	441	25	—	105
10	304	235	− 10	−110	−100	10,000	100	12,100	1,100	—
11	240	279	− 74	− 66	+ 8	64	5,476	4,356	4,884	—
12	262	298	− 52	− 47	+ 5	25	2,704	2,209	2,444	—
13	215	295	− 99	− 50	+ 49	2,401	9,801	2,500	4,950	—
14	300	315	− 14	− 30	− 16	256	196	900	420	—
15	298	282	− 16	− 63	− 47	2,209	256	3,969	1,008	—
16	391	355	+ 77	+ 10	− 67	4,489	5,929	100	770	—
17	283	366	− 31	+ 21	+ 52	2,704	961	441	—	651
18	265	285	− 49	− 60	− 11	121	2,401	3,600	2,940	—
Total ..	5,652	6,216	+366	+432	+270	28,808	41,962	55,396	35,031	756
	—	—	−366	−426	−264	1,600·4	2,331·2	3,077 6	756	—
	314·0	345 3	—	—	—	40 0	48·3	55·5	34,275	—
	—	—	—	—	—	—	—	—	1,904·2	—

exactly, the mean for Y is 345·3, or 31·3 grammes more than for X. We want to know how far this difference is "significant" in the statistical sense—*i.e.*, how its magnitude compares with the standard error of the mean difference determined from batches of eighteen plots *taken in comparable pairs in the same way.*

We have, therefore, first to calculate the standard deviation of the differences

$$D = Y - X.$$

Since

$$M_d = M_y - M_x$$

we have for the deviations

$$d = y - x$$

and

$$\sigma_d^2 = \frac{S(y-x)^2}{N}$$

In columns 4 and 5 of Table III. the deviations x and y are tabulated: the positive and negative deviations are totalled separately at the foot as a check. Since M_x is 314 exactly, the sum of the positive deviations of x and the sum of the negative deviations must be equal to each other. Since M_y is strictly $345\frac{6}{18}$ and we have taken deviations from the nearest whole number 345, the sum of the positive deviations of y must exceed the sum of the negative deviations by 6. In column 6 the differences $y - x$ are entered, and again checked by totalling the positive and negative deviations separately. Finally in column 7 the squares are entered, and totalled: the sum comes to 28,808: dividing this by 18, the number of differences, we have 1,600·4, and taking the square root

$$\sigma_d = 40·0$$

(We have ignored the small correction for the fact that M_d is not zero, as it is not appreciable if we only want three-figure accuracy). Hence, finally, by (6) the standard error of the mean difference, say ϵ_d is

$$\epsilon_d = \frac{40·0}{\sqrt{18}} = \frac{40·0}{4·24} = 9·43 \ldots\ldots\ldots\ldots (a)$$

The actual difference between the means is 31·3, and

$$\frac{31·3}{9·43} = 3·32$$

The difference being 3·32 times its standard error is almost certainly *significant;* that is to say, if we had a much more extensive series of such differences $y - x$, as are shown in Table III. with the same standard deviation 40·0, and took samples of 18 observations out of

it, the mean of a sample would not exceed 31·3 more than about once in 1,000 trials, owing merely to the fluctuations of sampling. (*Cf.* below, §§ 20 to 22 for further explanation.)

12. To emphasize the advantage gained by this procedure, and to emphasize also *why* we gain such advantage, it is desirable to do a little more arithmetic on these data. Let us determine the standard error of the difference between the two means by equation (11) instead. In columns 8 and 9 of Table III. the standard deviations of X and Y are worked out and found to be 48·3 and 55·5 respectively. (The correction for the fact that deviations in Y have not been taken from the true mean is again ignored as negligible.) Hence we have, adding their squares, taking the square root, and dividing by the square root of 18—

		2331·2
		3077·6
		5408·8
Square root	.. ..	73·54
divide by 4·24	.. ..	17·33

or

$$\epsilon_{12}=17·33 \ldots\ldots\ldots\ldots\ldots\ldots\ldots (b)$$

This procedure makes the standard error nearly twice what it was by (*a*):* $\frac{31·3}{17·3}$ is 1·81 only, and the observed difference would appear to be by no means certainly significant. The reason is that (11) or its arithmetical application (*b*) implies a totally different method of sampling from that implied by (*a*). The method used for (*a*) implies that we are sampling, as stated, from a *series of differences* like that observed, but more extensive, and we obtain the standard error of the *mean difference*. The method implies, therefore, that we have arranged our little plots in the way supposed, so that plots of the same number in each series are closely adjacent. The method used for (*b*) entirely ignores arrangement. It tells us merely that if we took a sample of eighteen plots at random from a series like that observed for X, with a standard deviation 48·3, and another sample of eighteen plots at random from a series like that observed for Y, with a standard deviation of 55·5; took the difference of the means of those samples, and so on for a number of such pairs of samples, the standard deviation of the difference of the means should be 17·3, or thereabouts. We obtain the standard error of *the difference*

* And even so it is hardly legitimate, for columns 2 and 3 are not random samples, and (8) rather than (6) is applicable for the standard error of each mean. See below, § 25.

between the means. The method has no concern with the arrangement of the plots. What we have done in case (*a*) is to insist that when we have picked out a plot of X for the first sample, we shall pick out a *closely adjacent plot* of Y for the second sample; this produces a correlation between the yields of plots with the same number, since soil conditions are similar in adjacent patches, and hence reduces the standard deviation of the differences. To complete the arithmetical investigation of the particular example, we have worked out the correlation. The products of deviations are given in columns 10 and 11 of Table III.: the algebraic sum is 34,275, and dividing by 18 we have the mean product 1,904·2. Hence

$$r_{xy} = +\frac{1904{\cdot}2}{48{\cdot}3 \times 55{\cdot}5} = +0{\cdot}71$$

This is, so far as our experience goes, rather a high correlation: lower values are more usual. Even negative values *may* occur.

The student should note that columns 8 to 11 of Table III. have been worked out for purely illustrative purposes. Columns 1 to 7 are all that is necessary for evaluating the standard error of the mean difference by the given method.

13. *Chessboard with a Number of Varieties.*—In §§ 11 and 12 we have only considered a single pair of varieties; usually, as already stated, a number are tested together. We might proceed exactly as in §§ 11, 12 for every pair. But even if as many as eighteen or twenty plots are given to each variety, this is a small number of observations on which to base a standard deviation, and little confidence can be placed on the differences between the rather diverse standard deviations that will be obtained from different pairs of varieties. It is, on the whole, better to use for every pair an *average* value of the variance (§ 4), obtained by considering all possible pairs of varieties. We may obtain this either by direct calculation—which may be a very lengthy process—or by a shorter formula which gives the same result. The direct process is illustrated first, as it follows from the work of the preceding paragraphs. Not to make the illustrative arithmetic too long, and to show its form completely, we have taken figures for six plots only of each of five varieties, extracted from the larger chessboard with eighteen plots. The data are given in Table IV. At the bottom of each column is given the mean for that variety. On the right are given the means for all the No. 1 plots, all the No. 2 plots, and so on, but those means are not at present required.

TABLE IV.—YIELDS OF GRAIN (IN GRAMMES) FROM PLOTS OF BARLEY OF 1 SQUARE YARD, CHESSBOARD, FIVE VARIETIES; SIX PLOTS OF EACH

Plot Number	*Variety.*					*Mean.*
	1	2.	3.	4	5	
1	387	372	350	340	398	369·4
2	420	455	417	360	358	402·0
3	353	375	400	358	334	364·0
4	331	328	325	370	340	338·8
5	358	383	378	395	320	366·8
6	400	308	275	375	430	357·6
Mean	374·8	370·2	357·5	366·3	363·3	366·4

14. *Direct Calculation of the s. d. of Differences for all Possible Pairs of Varieties.*—A fresh table is first drawn up, giving the deviations of each plot of each variety from the mean of that variety; for the present purpose it will be quite good enough to take the mean to the nearest whole number. These deviations are shown in Table V.: as in columns 4 and 5 of Table III., the positive and negative deviations are totalled separately to check the work. Next, the column for every variety is taken in turn with that for every other, and the differences are written down (as in column 6 of Table III.). These differences are shown in column 2 of Table VI., the deviation of the first variety having always been subtracted from that of the second; they should be checked (as in column 6 of Table III.) by totalling separately the positive and negative differences, but these

TABLE V.—DEVIATIONS OF THE YIELDS IN TABLE IV. FROM THE MEANS OF THE RESPECTIVE VARIETIES.

Plot Number.	*Variety and Value taken as "Rough Mean"*				
	1. 375	2 370.	3 357	4. 366.	5 363.
1	+ 12	+ 2	− 7	− 26	+ 35
2	+ 45	+ 85	+ 60	− 6	− 5
3	− 22	+ 5	+ 43	− 8	− 29
4	− 44	− 42	− 32	+ 4	− 23
5	− 17	+ 13	+ 21	+ 29	− 43
6	+ 25	− 62	− 82	+ 9	+ 67
Check Totals	+ 82 − 83	+ 105 − 104	+ 124 − 121	+ 42 − 40	+ 102 − 100

TABLE VI.—CALCULATION, FROM THE DATA OF TABLE V., OF THE STANDARD DEVIATION OF DIFFERENCES FOR ALL POSSIBLE PAIRS OF VARIETIES TOGETHER

1	2	3	1	2	3
Pair of Varieties	*Difference Deviation*	*Square*	*Pair of Varieties*	*Difference Deviation*	*Square*
1 and 2	− 10	100	2 and 4	28	784
	+ 40	1,600		− 91	8,281
	+ 27	729		− 13	169
	+ 2	4		+ 46	2,116
	+ 30	900		+ 16	256
	− 87	7,569		+ 71	5,041
1 and 3	− 19	361	2 and 5	+ 33	1,089
	+ 15	225		− 90	8,100
	+ 65	4,225		− 34	1,156
	+ 12	144		+ 19	361
	+ 38	1,414		− 56	3,136
	− 107	11,449		+ 129	16,641
1 and 4	− 38	1,444	3 and 4	− 19	361
	− 51	2,601		− 66	4,356
	+ 14	196		− 51	2,601
	+ 48	2,304		+ 36	1,296
	+ 46	2,116		+ 8	64
	− 16	256		+ 91	8,281
1 and 5	+ 23	529	3 and 5	+ 42	1,764
	− 50	2,500		− 65	4,225
	− 7	49		− 72	5,184
	+ 21	441		+ 9	81
	− 26	676		− 64	4,096
	+ 42	1,764		+ 149	22,201
2 and 3	− 9	81	4 and 5	+ 61	3,721
	− 25	625		+ 1	1
	+ 38	1,444		− 21	441
	+ 10	100		− 27	729
	+ 8	64		− 72	5,184
	− 20	400		+ 58	3,364
Total	—	—	—	—	161,420

check-totals have been omitted to save space. When these differences have been obtained and checked, the squares are next entered in column 3 and totalled. The total is 161,420, and the number of differences is 60, hence—

$$\sigma_d^2 = \frac{161,420}{60} = 2,690 \cdot 3$$

$\sigma_d = 51 \cdot 87 =$ standard deviation of the differences between comparable plots.

Hence, finally, for the standard error of mean difference based on six pairs of plots, we have—

$$\epsilon_d = \frac{51 \cdot 87}{\sqrt{6}} = 21 \cdot 2 \quad \ldots\ldots\ldots\ldots\ldots\ldots (a)$$

Variety 1 shows the greatest mean yield (374·8 grammes), and Variety 3 shows the lowest (357·5 grammes): difference, 17·3 grammes. This is less than the standard error, so that on this small test, with six plots only, none of the varieties appear to be significantly different.

15. At this stage we may ask ourselves, as in the case of Table III., whether we have gained anything by working in this way. Have we, that is to say, got a standard error at all smaller than we would have obtained by simply comparing the means of two groups

TABLE VII.—SQUARES OF THE DEVIATIONS OF TABLE V. FOR CALCULATION OF σ_v.

Plot Number.	*Variety.*				
	1.	2.	3.	4.	5.
1	144	4	49	676	1,225
2	2,025	7,225	3,600	36	25
3	484	25	1,849	64	841
4	1,936	1,764	1,024	16	529
5	289	169	441	841	1,849
6	625	3,844	6,724	81	4,489
Totals ..	5,503	13,031	13,687	1,714	8,958
Grand total	—	—	—	—	42,893

of six plots taken at random, without respect to their order? To answer this question we will work out an average variance for the plots of a variety from the data of Table V. Table VII. shows the squares of the deviations, of which the grand total is 42,893. Dividing by the number of plots, thirty, we have—

$$\sigma_v^2 = \frac{42,893}{30} = 1,429 \cdot 8$$

$$\sigma_v = 37 \cdot 8,$$

where we have used σ_v^2 to denote this quantity, the average variance of a *variety* round its own mean. The standard error of the difference of two means is therefore by (10)—

$$\epsilon_{12} = \frac{37 \cdot 8\sqrt{2}}{\sqrt{6}} = \frac{53 \cdot 5}{\sqrt{6}} = 21 \cdot 8 \quad \ldots\ldots\ldots\ldots (b)$$

This is little more than the value given by (*a*), so the gain in this case is very small. But the selection of six plots, out of the eighteen that

were actually used, which was made to give a brief illustrative example, has by chance been unfortunate, for the complete data show a considerable gain (see below, § 17).

16. *Brief Method of Calculating the s. d. of Differences for all Possible Pairs of Varieties.*—With many varieties the method of the last paragraph involves very lengthy calculations. Thus, if we have eight varieties, the number of pairs is $\frac{n(n-1)}{2}$ or 28; with nine varieties it is 36, and with eighteen pairs of plots this would mean 504 differences to be worked out and their squares written down in the first case, and 648 in the second. Nevertheless, this was the way the work had to be done until quite recently; it could only be abbreviated if one was content with a rough standard deviation, obtained, *e.g.*, by using only a selection of all the possible pairs of varieties. "Student" (*Biometrika*, xv.), with the aid of R. A. Fisher, has now indicated a brief method. We will first give the formula (slightly modified from his) and indicate its use, and then give a proof for those who care to follow it. Let σ_d^2, as in § 14, be the mean variance of differences between comparable plots, which it is desired to find. Let σ_v^2, as in § 15, be the mean variance of yield for a variety round its own mean. Let σ_p be the standard deviation of the means for plots of the same number, as given on the right of Table IV. And, finally, let m be the number of varieties. Then—

$$\sigma_d^2 = \frac{2m}{m-1}(\sigma_v^2 - \sigma_p^2) \quad \ldots\ldots\ldots\ldots (12)$$

We have already found σ_v (§ 15): $\sigma_v^2 = 1{,}429{\cdot}8$. The work for σ_p is given in Table VIII., and we have $\sigma_p^2 = \frac{2{,}121{\cdot}48}{6} = 353{\cdot}6$: $\sigma_p = 18{\cdot}8$.

Hence, as $m=5$,

$$\sigma_d^2 = \frac{10}{4}(1{,}429{\cdot}8 - 353{\cdot}6) = 2{,}690{\cdot}5.$$

The trifling difference from the previous result (2,690·8) is due to the use of rough values for the means and the omission of corrections.

It is evident that this way of working represents an immense gain. To repeat the steps that are necessary: (1) Tabulate the yields on the plots of the chessboard as in Table IV. (2) Draw up a new table, as Table V., giving the deviations of the yields of each variety on each plot from the mean of that variety. (3) From this table find σ_v^2, as Table VII. (4) From the means on the right of the table in the form of Table IV. find σ_p^2, as in Table VIII. (5) The equa-

TABLE VIII.—CALCULATION OF σ_p, THE STANDARD DEVIATION OF THE MEANS OF PLOTS OF THE SAME NUMBER. DATA OF TABLE IV., RIGHT-HAND COLUMN.

Plot Number.	*Data (Table IV.).*	*Deviations.*	*Squares.*
1	369·4	+ 3·0	9·00
2	402·0	+ 35·6	1,267·36
3	364·0	− 2·4	5·76
4	338·8	− 27·6	761·76
5	366·8	+ 0·4	0·16
6	357·6	− 8·8	77·44
—	—	+ 39·0	2,121·48
—	366·4	− 38·8	353·58

tion (12) gives σ_d, the standard deviation of differences, and if n be the number of plots used for each variety, $\frac{\sigma_d}{\sqrt{n}}$ is the standard error of the mean difference.

17. We may conclude the arithmetical examples by giving some figures for the actual standard errors that have been obtained with the chessboard, using twenty plots for each variety. We give the standard errors by both methods of working, so as to show the gain by comparing adjacent plots.

Chessboard Trial.	(1) $\frac{\sigma_p\sqrt{2}}{\sqrt{20}}$	(2) $\frac{\sigma_d}{\sqrt{20}}$
1	12·8	10·1
2	14·1	11·6
3	15·1	10·4

All the data refer to plots of one yard square, as stated, with the same number of seeds sown in each. Results Nos. 1 and 2 refer to two chessboards (barley) at Cambridge: No. 2 is the chessboard from which six plots for five varieties were extracted for the preceding example, but the number of plots has been taken as twenty (instead of the actual number, eighteen) for the sake of comparability. The data for No. 3 are taken from "Student's" *Biometrika* paper, and refer to a chessboard of Dr. Beaven's. All give standard errors, in very close agreement, of a little over 10 grammes or 3·4 per cent. of the mean yield. The gain by comparison of adjacent plots is in each case considerable. It is most considerable in No. 3, where we would have to take double the number of plots in column 1, or more, to reduce the standard error to the value in column 2, since $\frac{(15\cdot1)^2}{(10\cdot4)^2}=2\cdot1$.

18. *Proof of Equation* (12).—Let the data be arranged as in Table A (that is, as in Table IV.), Y denoting the yield on any one plot, the first numerical subscript denoting the variety and the second the number of the plot. Let us derive from this a second table, Table B, as we derived Table V. from Table IV., by writing down the deviation of the yield on each plot of each variety from the mean of that variety. The mean of each column is now zero. The mean of

TABLE A.

Plot.	*Variety.*								*Mean.*
	1	2	3	.	.	.	.	m	
1	Y_{11}	Y_{21}	Y_{31}	.	.	.	.	Y_{m1}	P_1
2	Y_{12}	Y_{22}	Y_{32}	.	.	.	.	Y_{m2}	P_2
3	Y_{13}	Y_{23}	Y_{33}	.	.	.	.	Y_{m3}	P_3
.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.
n	Y_{1n}	Y_{2n}	Y_{3n}	.	.	.	.	Y_{mn}	P_n
Mean	M_1	M_2	M_3	.	.	.	.	M_m	M

TABLE B.

Plot.	*Variety.*								*Mean.*
	1	2	3	.	.	.	.	m	
1	v_{11}	v_{21}	v_{31}	.	.	.	.	v_{m1}	p_1
2	v_{12}	v_{22}	v_{32}	.	.	.	.	v_{m2}	p_2
3	v_{13}	v_{23}	v_{33}	.	.	.	.	v_{m3}	p_3
.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.
n	v_{1n}	v_{2n}	v_{3n}	.	.	.	.	v_{mn}	p_n
Mean	0	0	0	.	.	.	.	0	0

row r is p_r, where $p_r = P_r - M$: for the sum of the row, which was mP_r in Table A, is now—

$$mP_r - (M_1 + M_2 + \ . \ . \ . + M_m) = m(P_r - M).$$

From these tables we can derive five standard deviations for which we will use the following symbols.

1. The s. d. of the Y's round the general mean $M = \sigma_y$.

2. The s. d. of the variety-means M_1, M_2, etc., round the general mean $M = \sigma_m$.

3. The s. d. of the means of plots of the same number, P_1, P_2, etc., round the general mean $M = \sigma_p$.

4. The s. d. of the deviations v_{11}, v_{12}, v_{21}, etc., from the respective variety-means $= \sigma_v$.

5. The s. d. of the differences of the v's for plots of the same number, taking every variety with every other, $= \sigma_d$.

The last three are symbols that we have already defined and used, and σ_d is the quantity that we wish to determine. Using the direct method, as in the arithmetical example, § 14, we take every column of Table B in turn with every other, sum the squares of differences of the v's on the same line, and divide by their number $\frac{nm(m-1)}{2}$, thus obtaining—

$$\sigma_d^2 = \frac{2}{nm(m-1)} S(v_{rt} - v_{st})^2 \ldots\ldots\ldots\ldots (13)$$

Now consider the sum on the right-hand side. Every v^2 with a given suffix occurs $\overline{m-1}$ times, since each column is taken with every other. Hence, since for the whole table—

$$S(v^2) = mn\sigma_v^2,$$

we have—

$$\begin{aligned}\sigma_d^2 &= \frac{2}{nm} S(v^2) - \frac{2}{nm(m-1)} S(2v_{rt}\, v_{st}) \\ &= 2\sigma_v^2 - \frac{2}{nm(m-1)} S(2v_{rt}\, v_{st}) \ldots\ldots\ldots (14)\end{aligned}$$

Now consider the product-sum $S(2v_{rt}\, v_{st})$. For any one row of Table B each v is multiplied by every v except itself. Thus for v_{11} the sum of all the products involving it may be written—

$$v_{11}(mp_1 - v_{11}) = mp_1 v_{11} - v_{11}^2.$$

For the whole of the first row the sum of the products is therefore:

$$m^2 p_1^2 - S(v^2_{r1}).$$

But, extending the sum to the whole table—

$$\begin{aligned}&S(p^2) = n\sigma_p^2, \quad S(v^2) = mn\sigma_v^2 \\ &S(2v_{rt}\, v_{st}) = m^2 n\sigma_p^2 - mn\sigma_v^2 \ldots\ldots\ldots\ldots (15)\end{aligned}$$

and hence—

$$\sigma_d^2 = 2\sigma_v^2 - \frac{2m}{m-1}\sigma_p^2 + \frac{2}{m-1}\sigma_v^2 = \frac{2m}{m-1}(\sigma_v^2 - \sigma_p^2) \;\ldots (16)$$

which is our equation (12) of § 16. "Student" uses a different relation of a slightly different form. The distribution of *all* the yields is

compounded of the distributions for the several varieties, and hence [*cf.* Yule, "Introduction to the Theory of Statistics," chap. viii., § 11, equation (7)]—

$$\sigma_y^2 = \sigma_v^2 + \sigma_m^2 \quad \ldots\ldots\ldots\ldots\ldots (17)$$

and therefore we have—

$$\sigma_d^2 = \frac{2m}{m-1}(\sigma_y^2 - \sigma_m^2 - \sigma_p^2) \quad \ldots\ldots\ldots\ldots (18)$$

from which his equation for the standard error follows.* But (16) is a more convenient form for practical use. For (18) we have to calculate three standard deviations: σ_y which seems of no interest, σ_m the s. d. of varietal means, and σ_p the s. d. of plot-row means. For (16) we require only two standard deviations: σ_v which we ought to calculate in any case in order to test whether we are gaining anything by the chessboard method, and σ_p.

There is a gain by the chessboard method if—

$$2\sigma_v^2 > \frac{2m}{m-1}(\sigma_v^2 - \sigma_p^2)$$

$$\frac{2}{m-1}\sigma_v^2 < \frac{2m}{m-1}\sigma_p^2$$

$$\frac{\sigma_v^2}{\sigma_p^2} < m \quad \ldots\ldots\ldots\ldots\ldots\ldots (19)$$

Since σ_p increases with increasing heterogeneity of the soil, the improvement is the greater the greater the heterogeneity of the soil. The following are the data for the first two chessboards cited in § 17 and for the data used in the short example of §§ 13 to 16.

σ_v^2	σ_p^2	m
1,680·5	787·3	8
2,445·8	1,260·4	9
1,429·8	353·6	5

In the first two cases σ_v^2 is roughly about twice σ_p^2, while the values of m are 8 and 9 respectively, and the gain is consequently considerable: in the third case σ_v^2 is roughly nearly four times σ_p^2, while m is only five, and consequently the gain is slight (*cf.* § 15 and § 17).

19. In the preceding paragraphs we have been specifically considering the small-plot chessboard, such as is used for testing new varieties of cereals in the early stages. But such a scale of plots is not possible for some crops—*e.g.*, roots, or potatoes, or bush crops of any

* But by taking the standard error as $\frac{\sigma_d}{\sqrt{n-1}}$ not $\frac{\sigma_d}{\sqrt{n}}$. "Student's" σ_y is my σ_y; his σ_x is my σ_m; his σ_s is my σ_p.

kind; and even in the case of cereals the treatment is so artificial—the seeds being sown separately with wide spacing—that the trials on the small-plot chessboard must be followed or accompanied by trials under field conditions. The statistical methods to be followed will, however, be broadly the same in any case. Whatever the size or shape of plot adopted, a number of plots of each variety to be tested must be sown or planted; this number should if possible be the same for each variety, and the plots should be arranged as far as possible in the same way as for the small-plot chessboard—*i.e.*, so that a number of pairs of *comparative* plots can be obtained. The investigator who follows carefully the descriptions of the preceding paragraphs will, we think, be able to adapt the methods to his own case, though the exigencies of practice may cause him some difficulties—*e.g.*, if the amount of seed available is much more for some varieties than for others, so that the number of plots cannot be the same for all. In such a case the short method of § 16 cannot be used, but the investigator must use the method of Table VI., using (if not all possible) as many pairs of varieties as he thinks necessary to give him a fairly trustworthy value for the essential σ_d. It is not possible in a short article to deal with all the minor points that may arise.

20. In any given case, then, the investigator finds a certain mean difference, say $\bar{d}$, between the yields of two varieties, he has determined σ_d, and thence—

$$\epsilon_d = \frac{\sigma_d,}{\sqrt{n}}$$

the standard error of the mean difference; n being the number of pairs of plots from which $\bar{d}$ was found. The "significance" of the difference is then given by $\frac{\bar{d}}{\epsilon_d}$—the ratio of the mean difference to its standard error. We have tacitly assumed in some sentences of the preceding work that the reader had already some knowledge of the method of estimating significance from the value of $\frac{\bar{d},}{\epsilon_d}$ but for the sake of completeness we explain the method below.

21. *Significance of a Given Difference.*—Suppose that we had, as in § 4, carried out a long experiment in sampling from the record of yields on a very large number of plots, but had taken samples *in pairs* and worked out the difference (first mean less second mean) for each pair. We could then book up the frequency distribution of these differences, and we know its standard deviation ϵ_d. But we want to know more than this: we want to know how often a deviation of a given

magnitude is likely to occur, and we cannot tell this unless we know the *form* of the frequency distribution as well as its standard deviation. This form is usually assumed to be that of the "normal curve of errors," a curve in which the frequency tails away symmetrically in both directions from the mean. For this curve the fractions into which it is divided by an ordinate erected at any deviation $\frac{x}{\sigma}$ can be calculated once for all. The best table is given in "Tables for Statisticians and Biometricians," Part I. (Cambridge University Press, price 15s. net): for the sake of illustration we give a short table, Table IX.,

TABLE IX.—TABLE SHOWING THE GREATER FRACTION OF THE AREA OF A NORMAL CURVE OF ERRORS TO ONE SIDE OF AN ORDINATE AT THE ABSCISSA $\frac{x}{\sigma}$. AN ORDINATE AT A DEVIATION OF 2σ FROM THE MEAN, FOR EXAMPLE, DIVIDES THE AREA OF THE CURVE IN THE PROPORTIONS 0·97725 TO 0·02275.

$\frac{x}{\sigma}$	*Greater Fraction of Area.*	$\frac{x}{\sigma}$	*Greater Fraction of Area.*
0	0·50000	2·1	0·98214
0·1	0·53983	2·2	0·98610
0·2	0·57926	2·3	0·98928
0·3	0·61791	2·4	0·99180
0·4	0·65542	2·5	0·99379
0·5	0·69146	2·6	0·99534
0·6	0·72575	2·7	0·99653
0·7	0·75804	2·8	0·99744
0·8	0·78814	2·9	0·99813
0·9	0·81594	3·0	0·99865
1·0	0·84134	3·1	0·99903
1·1	0·86433	3·2	0·99931
1·2	0·88493	3·3	0·99952
1·3	0·90320	3·4	0·99966
1·4	0·91924	3·5	0·99977
1·5	0·93319	3·6	0·99984
1·6	0·94520	3·7	0·99989
1·7	0·95543	3·8	0·99993
1·8	0·96407	3·9	0·99995
1·9	0·97128	4·0	0·99997
2·0	0·97725	4·1	0·99998

below, and the investigator may find this enough for much of his work. The table shows the *greater* fraction of the two into which the given ordinate divides the curve. For example, if an ordinate is erected at a distance of 2σ from the mean, the greater fraction is—

0·97725,

and therefore in the tail of the curve beyond $\frac{x}{\sigma}$ the fraction is—

0·02275.

We usually, as a matter of fact, are concerned with the area in the *two* tails—*e.g.*, outside the limits $\pm 2\sigma$, and this is twice the above, or—

$$0{\cdot}04550.$$

That is to say, the probability P of deviations *of either sign* exceeding the limits $\pm 2\sigma$ is 0·0455.

Now suppose the investigator finds in a given case $\frac{\bar{d}}{e_d}$ is 2·15. From the table he finds by simple interpolation—

Greater fraction	·98412
In one tail	·01588
In two tails..	·03176

and can state the result briefly as P = 0·032. That is to say, the chance of an equal or greater difference occurring as a mere fluctuation of sampling (the means of the varieties being really identical) is only about $\frac{3}{100}$—only about three pairs of samples in 100 should show such a difference. Or, in other words, the odds *against* such a difference occurring as a fluctuation of sampling are about 97 to 3, or say 32 to 1. This gives precision to the result. But the table must be used with caution. It definitely assumes that the distribution of errors of sampling is of the normal form. This is only true if the distribution of the yields of the single plots is of the normal form; or alternatively if, when the distribution for the single plots is not normal but asymmetrical, the number of observations in the samples is large—and the larger the greater the original asymmetry. The frequency distribution of *means of samples* is always more symmetrical than the original distribution, and the approach to symmetry is the closer the larger the number of observations in the sample.

22. For a good deal of work the investigator will hardly find it necessary to use the table at all. He should endeavour to accustom himself to thinking roughly in terms of the standard error, guided by the values of P corresponding to a few values of $\frac{x}{\sigma}$. Thus the following can be remembered without much difficulty:

1. Half the observations are included within a range of about $\pm\frac{2}{3}\sigma$ (more precisely $0{\cdot}674489\sigma$).

2. About $\frac{2}{3}$ of the observations are included within the range $\pm\sigma$: more precisely the fraction is 0·6827 . . . .

3. Only about $\frac{1}{10}$ of the observations lie *outside* the range $\pm 1\frac{2}{3}\sigma$: more precisely the range is $\pm 1{\cdot}645\sigma$.

4. Only about $4\frac{1}{2}$ per cent. of the observations lie outside the range 2σ. The actual fraction is more precisely 0·0455: as a mnemonic,

to relate it to the fraction $\frac{2}{3}$ that occurs in the preceding rules, it can be thought of as about $\frac{1}{10}\left(\frac{2}{3}\right)^2$.

5. Only two or three (more nearly 2·72) observations per thousand lie outside the range $\pm 3\sigma$: the fraction is rather less than $\frac{1}{100}\left(\frac{2}{3}\right)^3$.

6. Only about one observation per thousand lies outside the range $\pm 3\frac{1}{4}\sigma$. More precisely the range is $\pm 3{\cdot}29\sigma$.

If he bears these rough rules in mind the investigator can place the significance of a given deviation approximately without reference to the table. It is evident that a difference cannot be regarded with any *very* great confidence as significant unless it exceeds three times its standard error.

23. The quantity $0{\cdot}674489\sigma$, which gives the range containing half the observations, is termed the *probable error*. The "probable error" has a simple significance, for greater and smaller deviations are equally likely to occur owing to fluctuations of sampling. Hence it used to be the established custom to state the probable error rather than the standard error. But multiples of the probable error have no simple meaning; one cannot regard a difference as probably "significant" which merely exceeds its probable error, and all normal curve tables are drawn up in terms of the standard error, not the probable error. Statement of the probable error in modern work is an unmitigated nuisance, and the investigator is recommended to confine himself to the standard error and accustom himself to thinking in terms of it.

24. If a number of different varieties have been tested, the yields may conveniently be listed in order, as in Table X., which gives the results of one of the chessboard trials of barleys at Cambridge. The varieties are ranked in order of yield. In the second column the mean yields are given in grammes. In the third column are shown the differences between the yields of the successive varieties, and in the third column these differences are expressed in terms of the standard error. There were twenty plots to each variety, σ_d was 45·18, and therefore—

$$\epsilon_d = \frac{\sigma_d}{\sqrt{20}} = 10{\cdot}1$$

The largest differences between consecutive varieties are those between the two varieties at the top and the two at the bottom of the list: both these differences exceed twice the standard error of the difference, and the odds are considerable that, *under the precise conditions of this test*, 3 is really a better yielder than 2, and 6 a better yielder than 4. The consecutive differences between all the varieties from 2 down to 6 are all small: their total is only 2·85, so

TABLE X.—RESULTS OF A CHESSBOARD TRIAL (PLOTS OF ONE SQUARE YARD) OF EIGHT VARIETIES OF BARLEY.

Variety.	*Yield in Grammes.*	*Differences.*	*Difference divided by Standard Error.*
3	339·4	—	—
2	317·6	21·8	2·16
8	311·2	6·4	0·63
1	310·8	0·4	0·04
5	308·8	2·0	0·20
7	299·6	9·2	0·91
6	297·5	2·1	0·21
4	272·5	25·0	2·48

there are fair odds that 2 is better than 7 or 6, but we cannot be at all sure that it is better than the intermediate varieties. We cannot be very sure that 8 is better than any variety except 4. No. 3 is rather conspicuously at the top: *probably* better than *all* the others, almost certainly better than all from No. 1 downwards. But all these conclusions, of course, are only true for the particular type of soil on which the test was conducted, and the weather conditions that ruled during the test—one may even add, possibly, the conditions under which the previous crop was grown and the seed harvested.

25. *Limitations of the Formulæ.* (*a*) *Theoretical.*—The last sentence indicates the necessity for some further consideration of the limitations of the formulæ. In the first place they only hold good if the conditions from which they were deduced hold good. Equation (6) is only applicable if the sample of n observations is a random sample. Well, for one thing, in a random sample, the deviations of successive observations in the sample from the mean of the sample should not show any definite order—*i.e.*, successive contributions to the sample should not be correlated with one another. Consider, as an example, the samples of Table III. The deviations of X are all positive at the top of the list, and nearly all negative at the bottom of the list: and the same thing holds for the deviations of Y. Neither of these samples, then, appears to be a random sample from the field, and in view of what has previously been said we have no right to expect it to be, for all the little plots are close to one another. As already stated, therefore, in the footnote to § 12, we were not justified in using equation (6) as giving the standard error of each of the means: equation (8) is *applicable*, but we cannot *apply* it for we do not know the average correlation r. The deviations of the differences, $y-x$, on the other hand, in column 6, do not show any obvious order:

taking the sign of each with the sign of the one that follows, eight out of the seventeen pairs are of the same sign and nine are of opposite sign. This does not suggest any appreciable correlation between consecutive differences, and actually if we work it out we find r only −0·074. We seem justified accordingly in using the equation—

$$\epsilon_d = \frac{\sigma_d}{\sqrt{n}}.$$

But we might not have been justified, and it is desirable to examine the series of differences and see whether it looks approximately random, even if no more stringent test is applied. Certain arrangements of plots might quite well lead to a correlated series. Suppose, for example, that the plots for a variety A were all in a row running North and South, and the plots of variety B in a similar row beside it. Then, if a streak of more fertile soil happened to pass across from the West to the East side of the double row in the course of its length, A might be the better yielder on all the pairs of plots at the north end, and B the better yielder on all the pairs at plots at the south end: the series of differences would be a correlated series and not a random series, and the formulæ inapplicable.

26. Similarly, it is always desirable to examine the figures, as already suggested in §§ 12, 15, and 18, to see whether the method of working with pairs of closely adjacent plots is giving any apparent advantage—that is to say, whether the yields on such pairs of plots are, in fact, correlated. With plots of larger size, at least, this may not always be the case. We have in mind, as an example, a plot test of potatoes which was carried out at Cambridge some years ago. The data are, unfortunately, not now available, so that we cannot give precise figures, but the correlation between corresponding plots came out distinctly—if not significantly—*negative*. One might imagine such a negative correlation arising if manure had been carted on to the field and left in heaps for a few days, before spreading, during rain. Supposing the heaps to be just at such distances apart that a plot with a heap on it was unlikely to have any neighbour with a heap on it also, a plot with a high yield would tend to be surrounded by plots with relatively low yields—*i.e.*, the correlation would be negative. A very irregularly patchy soil will always tend to give relatively low correlations, and a very homogeneous soil also.

27. *Limitations of the Formulæ.* (*b*) *Practical: Weather Sampling.*— Even more important limitations in the interpretation of the results given by the formulæ arise from the fact that all through the preceding work, from the very beginning of this article, we have only been con-

sidering the effect of variability of the soil-conditions. But the *relative* as well as the absolute yields of two varieties are dependent also upon the weather: one year may suit variety A better than variety B, and another may suit B better than A. If two sowings on different dates are made in the same year, the earlier may suit one variety, the later may suit another. The *one* trial, as we have already emphasized, can only give information as to the relative yields under the particular circumstances of that trial. Table XI. gives data for two varieties of barley on chessboards of 1912, when

TABLE XI.—RESULTS OF TWO DIFFERENT SOWINGS ON BARLEY CHESSBOARDS IN 1912.

	First Sowing.	*Second Sowing.*
1. Variety A: mean yield, grammes	339·4	309·6
2. Variety B: ,, ,, ,, ...	297·5	332·1
3. Difference of mean yields, A-B	+41·9	−22·5
4. Number of plots	20	10
5. Standard error of mean difference	10·1	16·7
6. Difference/standard error	+ 4·15	− 1·35
7. P	0·00002	0·177

two sowings were made at a fortnight's interval. On the results of the earlier sowing the yield of A exceeds that of B by over four times the standard error of the difference. We would have reckoned A as almost certainly the better variety, since the chance of such a difference occurring as a fluctuation of sampling is only about 1 in 50,000. But on the second sowing B appears the better yielder, though the difference is hardly significant, as it is only 1·35 times the standard error.

28. Table XII. gives another illustration of similar inconsistence, from chessboards in the two years 1912 and 1913. In 1912 variety A was placed as almost certainly better than either C or D, since the difference of yields is over three times its standard error in the first case, and nearly four times its standard error in the second case.

TABLE XII.—RESULTS OF CHESSBOARD TRIALS IN 1912 AND 1913

	1912.	1913.
1. Variety A: mean yield, grammes	339·4	345·3
2. Variety C: ,, ,, ,, ...	308·8	358·7
3. Variety D: ,, ,, ,, ...	299·6	345·6
4. Difference of mean yields, A-C	+30·6	−13·4
5. ,, ,, ,, A-D	+39·8	− 0·3
6. Number of plots	20	18
7. Standard error of mean difference	10·1	12·2
8. Difference A-C/standard error	+3·03	−1·10
9. Difference A-D/standard error	+3·94	−0·025
10. P for (8)	0·0025	0·27
11. P for (9)	0·00008	0·98

But in 1913 none of the three yields proved significantly different, the yield of A being actually the lowest of the three. It may be added that the second sowing of 1912 gave mean yields in the same order as the first sowing, though C and D were practically identical. We have not thought it worth while complicating the table with full details, but the means were: A, 309·6; C, 288·2; D, 287·9

29. In view of such results, it may well be asked, what is the value of these elaborate tests? The answer, though it may seem pessimistic to some, must be, we think, that it is very little or, if the phrase is preferred, extremely limited. Even in so far as the investigator is concerned with yield alone—and usually he is equally concerned with other qualities—he is concerned with the *average relative yields* over successive years. The one trial can only give him the relative yields in the precise conditions under which it was conducted, and common-sense alone would suggest that this cannot be more than the roughest indication of relative yields under other conditions, even when soil-conditions are kept approximately the same.

30. But this does make it urgently desirable to try and form some estimate of the extent to which weather conditions may influence relative yields. No adequate data appear to exist; indeed, it would seem to be an extremely difficult matter to disentangle the effects of weather-variation and soil-variation. If some form of chessboard could be maintained for a number of years on unvarying soil with the same varieties, the question could be answered. But merely maintaining the same crop on the same area would itself alter the soil, and if the chessboard were shifted or the soil were manured this would introduce other variations. The value of the following investigations, which were begun by one of us before the War, is possibly limited, but we give them for what they are worth, as suggesting the sort of magnitude likely to be taken by the standard deviation that we seek.

31. *Investigation A. Three Barleys.*—The three barleys A, C, and D of Table XII. were grown on three chessboards: the earlier sown of 1912 (twenty plots); the later sown of 1912 (ten plots); and the chessboard of 1913 (eighteen plots). If we take all these results together, as if the plots had been sown in the same year, we get a value for σ_d^2 based on the three possible pairs AC, AD, and CD, which is compounded of the variance due to soil or ground conditions and the variance due to different weather conditions, and may be denoted by ${}_d\sigma_{w+g}^2$. If, on the other hand, we treat each chessboard separately as in the preceding work, but add the sums of squares of difference-deviations, we get a variance (an average value of the σ_d^2's for the several chessboards) which is due to ground conditions

only and may be denoted by ${}_d\sigma_g{}^2$. The variance due to weather differences alone is then given by

$$ {}_d\sigma_w{}^2 = {}_d\sigma_{w+g}^2 - {}_d\sigma_g{}^2 $$

The actual figures obtained, yield being measured in grammes as before, were:

$$
\begin{array}{lll}
 & {}_d\sigma_{w+g}^2 \;\ldots & 3386{\cdot}22 \\
 & {}_d\sigma_g{}^2 \;\ldots & 3139{\cdot}08 \\
\hline
\text{whence} & {}_d\sigma_w{}^2 & = 247{\cdot}14 \\
 & {}_d\sigma_w & = 15{\cdot}72 \text{ grammes.}
\end{array}
$$

The mean yield per plot being 324·3 grammes, ${}_d\sigma_w$ is 4·85 per cent. of the mean yield. The result does not seem unreasonable, but the basis is very limited. The plots have only been subjected to three different sets of weather conditions, and we have only three varieties. For the three pairs of varieties separately the data give—

	AC	AD	CD
${}_d\sigma_w$	20·09	17·77	4·70
M	329·3	324·9	318·9
$\frac{100\,{}_d\sigma_w}{M}$	6·10	5·47	1·47

and suggest that ${}_d\sigma_w$ may be very different for different pairs, as might be expected. If two differently named varieties were in fact identical, they should give a zero value for ${}_d\sigma_w$.

32. *Investigation B. Rothamsted Wheats. Eleven Years.*—In Sir Daniel Hall's "Account of the Rothamsted Experiments," p. 66, are given data for a number of wheats that were grown continuously at Rothamsted over the eleven years 1871-1881. For some of the wheats there are gaps in the record, but for fourteen of them the record of yield, which is given in bushels per acre, is complete. No details are given in the book, but in reply to my enquiry Sir John Russell wrote in 1914: "There is nothing to show the size of the plots, and we have not got the harvest books of the period. Mr. Dunkley's recollection is that the plots were one land wide (about 16 yards) adjacent to one another and running the whole length of the field. They were not taken in duplicate, and they were done on different fields each year. The area would probably vary from ¼ to ½ acre."

33. Evidently we have here data of a more ample kind for giving ${}_d\sigma_{w+g}$. We would, however, have liked more than eleven years, and we would have liked a set of years that did not include two such abnormal years as 1879 and 1880, when the mean yields of these fourteen wheats fell to 56 per cent. and 63 per cent. respectively of

the general average. To include two such abnormal years in so short a series seemed bound to give an unduly high figure for the effect of fluctuations in weather, and the data were therefore reworked with those two years omitted (below, § 35). But how are we to obtain ${}_d\sigma_g$, as plots were not duplicated? When the data were first considered no solution of this problem suggested itself, and it was decided to *assume* the figure of 5 per cent. (of the mean yield) as the standard deviation for large plots (*Cf.* Table II.), which gives, remembering that this has to be multiplied by $\sqrt{2}$ to obtain the standard deviation of differences

$${}_d\sigma_g^2 = \cdot 005\ M^2.$$

But there was always some discomfort in using this result, as there was no certainty that the figure should not be larger. It was not until the present article was being written that a simple method suggested itself for estimating ${}_d\sigma$ from the data. If we can pick out a few years in which the mean yields (for all the varieties together) were almost the same, it seems fair to assume that in those years the weather conditions were also appreciably similar. We can then treat the separate years as plots and obtain ${}_d\sigma_g$—*i.e.*, the σ_d of previous work, as in § 16. In so far as our assumption that weather conditions may be regarded as appreciably similar is wrong, this way of working will give us too high a value for ${}_d\sigma_p$, and our answer will therefore be on the safe side—*i.e.*, it will not lead to too high a value for ${}_d\sigma_w$. The three years 1872, 1876, and 1877 were found to give nearly the same mean yields—viz., 43·27, 42·19, and 42·14 bushels per acre, and were used for this purpose. They gave—

$${}_d\sigma_g^2 = 5\cdot 6073$$
$${}_d\sigma_g = 2\cdot 368 \text{ bushels per acre}$$
$$= 5\cdot 57 \text{ per cent. of the mean yield.}$$

This is a *lower*, not a higher, figure than we had previously assumed (since $5\sqrt{2}$ is 7·07) and it gives a standard deviation for single plots of just under 4 per cent. of the mean. As it seems to us, however, it must be too high rather than too low: nevertheless we give for comparison the results obtained on the basis of the 5 per cent. assumption. The figure for ${}_d\sigma_{w+g}$, if the work had been done now, would have been obtained by the short method of § 16, treating years as plots, but this method had not been invented before the War, and it was actually calculated by the direct method of § 14, using all the possible (ninety-one) pairs of the fourteen varieties.

84. The following are the results:

Mean yield $=38{\cdot}867$ bushels per acre

(a) Assumed ${}_d\sigma_g^2 = {\cdot}005\ \mathrm{M}^2$ (§83)

$$\begin{aligned}
{}_d\sigma_{w+g}^2 &= 26{\cdot}8116 \\
{}_d\sigma_g^2 &= 7{\cdot}5532 \\
{}_d\sigma_w^2 &= 19{\cdot}2584 \\
{}_d\sigma_w &= 4{\cdot}388 \text{ bushels per acre} \\
&= 11{\cdot}29 \text{ per cent. of mean yield.}
\end{aligned}$$

(b)

$$\begin{aligned}
{}_d\sigma_g &= {\cdot}0557\ \mathrm{M};\ {}_d\sigma_g^2 = {\cdot}0031025\ \mathrm{M}^2 \\
{}_d\sigma_{w+g}^2 &= 26{\cdot}8116 \\
{}_d\sigma_g^2 &= 4{\cdot}6868 \\
{}_d\sigma_w^2 &= 22{\cdot}1248 \\
{}_d\sigma_w &= 4{\cdot}704 \text{ bushels per acre} \\
&= 12{\cdot}10 \text{ per cent. of mean yield.}
\end{aligned}$$

The results do not greatly differ and make ${}_d\sigma_w$ some 11 or 12 per cent. of the mean yield, more than double the value given by the three barleys tested under chessboard conditions. But while we should suspect the latter value of being too low, we also suspect the values above of being almost certainly too high, owing to the inclusion of the abnormally bad seasons 1879 and 1880, when the relative yields were also markedly erratic. We proceed accordingly to the further work in which the harvests of these years were left out of account.

85. *Investigation C. Rothamsted Wheats. Nine Years.*—Omitting the years 1879 and 1880 in which the harvest failed so badly, and retaining only the remaining nine more normal years, the work was repeated on precisely the same lines, with the following results:

Mean yield $=42{\cdot}430$ bushels per acre

(a) Assumed ${}_d\sigma_g^2 = {\cdot}005\ \mathrm{M}^2$

$$\begin{aligned}
{}_d\sigma_{w+g}^2 &= 16{\cdot}3845 \\
{}_d\sigma_g^2 &= 9{\cdot}0015 \\
{}_d\sigma_w^2 &= 7{\cdot}3830 \\
{}_d\sigma_w &= 2{\cdot}717 \text{ bushels per acre} \\
&= 6{\cdot}40 \text{ per cent. of mean yield.}
\end{aligned}$$

(b)

$$\begin{aligned}
{}_d\sigma_g^2 &= {\cdot}0031025\ \mathrm{M}^2 \\
{}_d\sigma_{w+g}^2 &= 16{\cdot}3845 \\
{}_d\sigma_g^2 &= 5{\cdot}5854 \\
{}_d\sigma_w^2 &= 10{\cdot}7991 \\
{}_d\sigma_w &= 3{\cdot}286 \text{ bushels per acre.} \\
&= 7{\cdot}74 \text{ per cent. of mean yield.}
\end{aligned}$$

The values now obtained for ${}_d\sigma_w$ are more modest: the 5 per cent. assumption makes it roundly about 6½ per cent. of the mean yield; the value of ${}_d\sigma_g$ deduced from the data themselves makes it 7¾ per cent. of the mean yield.

36. Of the five values obtained for ${}_d\sigma_w$, we have little doubt that this last is the best founded. For the value, roundly 5 per cent., founded on the three barleys, the basis is extremely slight. The values of 11 and 12 per cent. obtained in § 34 are founded on the largest number of years, but the series of years includes two such exceptionally bad harvests that these figures are almost certainly exaggerated. The figure 6·40 per cent. is based in part on a pure assumption as to the value of ${}_d\sigma_g$. But the last figure 7·74, or roundly 7¾, per cent. involves no such arbitrary assumption, and is based on a good number of varieties (fourteen) and at least a modest number of years (nine). We suggest that it can be accepted as at least a fair approximation to an average for cereals in England. It does not seem an unreasonable figure. If fluctuations may be taken to a first approximation as normal, it implies that two varieties, which are different but give the same yield in the long run, are not likely to differ from one another in yield by more than about ±5¼ per cent. in one year out of two or by more than ±7¾ per cent. in more than one year out of three. About once in a century the yield of A might exceed that of B by as much as 18 per cent. or more. About once in a century the yield of B might exceed that of A by 18 per cent. or more. It is quite easy to find wilder fluctuations than this in the Rothamsted record, though we must, of course, remember that ground variance is also at work. On the average of the nine normal years the yield of Bristol Red is to that of Red Nursery as 107 to 100; but in 1873 the ratio is 146 to 100, in 1874 it is 130 to 100, and in 1875 only 81 to 100. On the average of the same nine years the yield of Club Wheat (Red) is to that of White Chiddam as 127 to 100: in 1878 the ratio is 149 to 100, in 1881 it is only 92 to 100, and so on.

37. Most previous writers have duly emphasized the fact that the standard error obtained from the chessboard (in any of its forms) takes into account variations in the soil or ground alone, and not the further source of fluctuations in relative yields—viz., the vagaries of the weather. But they must, we think, have tacitly assumed that the effect of the vagaries of the weather was comparatively small, for attention seems to have been directed entirely to reduction of the first source of error, until it is claimed that for some types of parallel-strip comparison the standard error may be reduced to little more than one-half of one per cent. Such a claim seems to us seriously misleading. The *effective* standard error, taking into account both possible sources of error, is for a comparison in a single year given by—

$${}_de^2{}_{w+g} = {}_de_g^2 + {}_d\sigma_w^2,$$

TABLE XIII.—TABLE OF THE EFFECTIVE STANDARD ERROR OF A DIFFERENCE (EXPRESSED AS A PERCENTAGE OF THE MEAN YIELD) FOR VARIOUS VALUES OF THE TWO COMPONENTS.

Standard Error due to Ground Conditions.	*Standard Error due to Weather Fluctuations.*				
	5	6	7	7·75	8
0·5	5·02	6·02	7·02	7·77	8·02
1·0	5·10	6·08	7·07	7·81	8 06
2·0	5·39	6·32	7·28	8·00	8·25
3·0	5·83	6·71	7·62	8·31	8·54
4·0	6·40	7·21	8·06	8·72	8·94
5·0	7·07	7·81	8·60	9·22	9·43

and if ${}_d\epsilon_g$ is 0·6 per cent., ${}_d\sigma_w$ is 7·75 per cent., ${}_d\epsilon_{w+g}$ is 7 77 per cent. *The effective standard error cannot be less than ${}_d\sigma_w$, whatever this may be.* Table XIII. illustrates the case more generally. If the standard error for weather variations is as low as 5 per cent., a standard error due to ground conditions of 1 per cent. raises the effective standard error to 5·10 per cent. only. There is no point in trying to get ${}_d\epsilon_g$ any lower; and even if ${}_d\epsilon_g$=3 per cent., ${}_d\epsilon_{w+g}$ is no more than 5·83 per cent. And ${}_d\epsilon_g$ has its maximum effect for this low value of ${}_d\sigma_w$. If ${}_d\sigma_w$ is 8 per cent., the effective standard error is still under 9 per cent. when ${}_d\epsilon_g$ =4 per cent. We believe the effective standard error in a yield-trial of cereals in the United Kingdom is rarely less than 5 per cent. or so, and that a cautious worker will assume it at something more like 8 per cent., however low ${}_d\epsilon_g$ may be. Quite similar figures will probably apply elsewhere.

38. Am I then, the reader may be inclined to ask, really to ignore the standard error ${}_d\epsilon_g$, to the methods of determining which you have devoted so much space? Certainly not. Experiments must be so conducted—by some form of chessboarding or at least repetition of plots—that ${}_d\epsilon_g$ can be determined, or the investigator will not know where he stands. What we wish to emphasize is that attention must not be concentrated *solely* on ${}_d\epsilon_g$, for ${}_d\sigma_w$ may be even more important, and it is no use spending great pains on the endeavour to reduce the effects of one source of error when another is left uncontrolled and its effects unmeasured. The magnitude of ${}_d\sigma_w$ can only be determined for the specific case, and the effects of this source of error reduced, by continuing the trials for a number of years. If the trials are continued for k years, we will have—

$$ {}_d\epsilon^2_{w+g} = {}_d\epsilon_g^2 + \frac{{}_d\sigma_w^2}{k}, \quad \ldots\ldots\ldots\ldots\ldots (20) $$

where ${}_d\epsilon_o^2$ is now the value determined from all the chessboards jointly, averaging the values of σ_d^2 (weighted by the numbers of plots in the respective chessboards if these vary) and dividing by the total number of pairs of plots for any one pair of varieties. To continue the trials for a sufficient number of years to give ${}_d\sigma_w$ with any precision may be a counsel of perfection, but in the absence of definite information the investigator is thrown back on a pure assumption, such as the acceptance of our average figure for wheat at Rothamsted. The very different results given by the two chessboards at Cambridge in 1912 suggest that it may be possible to get some control in a shorter period of years, in the case of annuals, by sowing two or more chessboards on different dates in each year.

39. Anyway, we think we have justified our motto. It is nearly as difficult to make sure of the relative yielding capacities of two varieties as it is to get your ball through the hoop at a game of croquet, when the mallets are flamingos and the balls are hedgehogs.

SOUTHERN RHODESIA
REPORT ON THE COTTON SEASON, 1924-25

BY

G. S. CAMERON,
The Corporation's Cotton Specialist.

INTRODUCTORY

As the 1924-25 cotton-growing season may now be reckoned over I have considered it timely to present a report covering the period December 1924 to September 1925.

I should make it clear at the outset that what follows consists of my own opinions based on personal observations. Such opinions may not be in entire agreement with the generally accepted ideas of others connected with the cotton-growing industry in Southern Rhodesia who have had longer experience of the country than I am likely to have for some considerable time to come. An attempt shall be made, however, to point out where any divergence of views occurs, and it is hoped that, should the following come to the notice of any in Southern Rhodesia holding different views from the writer's, they will remember that he is a newcomer amongst them, and that, as time progresses, he may reconstruct many of the impressions which he has formed so far.

As a result of negotiations between the High Commissioner for Southern Rhodesia and the Empire Cotton Growing Corporation in London, I was sent out to render what assistance I could to the cotton-growing industry which was, and is still, in the process of being built up.

I was informed in my agreement that my duties would probably consist of advising farmers on matters relating to cotton cultivation and that the greater part of my time might be spent in travelling.

I arrived in Salisbury on November 25, 1924.

THE POSITION AT THE END OF 1924

One of the first phases of the industry which struck me on my arrival in Southern Rhodesia was the tremendous enthusiasm of the farming community and others towards cotton-growing. I gathered that the slump in cattle had been a severe blow to farmers in Southern

Rhodesia, many of whom had bought stock when prices were at their height. It was but natural that the advent of cotton as a possible crop for Southern Rhodesia was hailed from one end of the country to the other.

By a combination of favourable circumstances the 1923-24 cotton crop made such an impression on farmers and others that something resembling a cotton stampede took place at the beginning of the season under review.

The aforementioned favourable circumstances were the high prices realized by the lint, combined with the ease with which the crop was grown. Although the year turned out to be the driest on record, the rains were evenly distributed, and it must not be forgotten that, whilst the year in question was abnormally dry, it followed a wet year in which the bulk of the rain fell late in the season. This meant that the soil contained a fair amount of moisture at the beginning of the ensuing season.

By November 1924 it was estimated that 60,000 acres of cotton would be planted during the 1924-25 season, but the advent of early and plentiful rains caused an increase in the area which was originally estimated.

My first few days in Salisbury were spent in getting acquainted with the immediate vicinity and calling upon officials of the Government. It was not until December 3 that I was able to set out on my first tour. I was asked, officially, to inspect and report upon Triangle Ranch, which is situated about 100 miles south of Victoria. This was a piece of work which I did not feel like undertaking owing to my inexperience of the country, but it was pointed out that the report on Triangle Ranch had to be carried out by an official of the Empire Cotton Growing Corporation, as the financiers interested in the ranch were in London, and they wanted an independent report upon it. Mr. Milligan in the Union of South Africa was asked to report upon Triangle Ranch. He pointed out that his engagements would keep him in the Union until the end of March. Such being the case, I undertook to report on this property and set out for Victoria on December 3, a journey which took me three days, owing to the wet weather and the state of the roads, and one which I have subsequently performed in one day.

On arrival at Victoria I was informed by local officials that it would be unwise to attempt to proceed to Triangle Ranch, as there were several big rivers between, which might mean my being cut off on my return journey. Unfortunately, I did not listen to such advice, with the result that instead of returning in about a week's time as

anticipated, I did not get back to Victoria until January 17, having performed the last twenty-five miles of the journey by waggon and on foot; I had to abandon my car, which was not recovered until April.

In the intervening period between January and April I got around the country as best possible by train and by the use of hired transport. By this means I was able to get over a fair amount of country, but could never proceed any distance from the railway owing to the bad state of the roads.

The rainfall in the meantime was continuous, with the result that a good deal of the cotton which had been planted on light soils was being washed away; in other places it was feared that the excessive rainfall would damp off the cotton, but such did not turn out to be the case, and it was felt right up to April that there was still a possibility of the cotton crop turning out well, as, until that time, it had stood up against the excessive rains. At the beginning of April a few days of bright weather were experienced, and the majority of farmers were of opinion that the wet season had finished. Had such been so, it is likely that the report for this year would have been of a very different character, as, although bud and flower shedding had been fairly intensive, up till this date there was a sufficient number of both left to give indications of a good subsequent crop. Unfortunately the weather again broke down and April continued wet right up to the end of the month, and heavy rain was experienced even as late as May.

Up till this time the writer had hopes of a fairly good crop, although not nearly so heavy a crop as had been expected on his arrival. From this time onwards most of the crops visited appeared to have suffered rather severely, and it was only in one or two parts of the country that one felt there was any hope of a crop at all. These were chiefly in the Gatooma, Lomagundi and Bindura areas, where, incidentally, the farmers had decided to erect co-operative ginneries for themselves.

In addition to adverse climatic conditions the effects of indifferent seed which had been sown in the beginning of the year began to show by April and May. Not only did a number of plants show a tendency to excessive shedding of buds, flowers and bolls, but a large number proved to be barren plants which looked as if they would never have produced any quantity of cotton even in the best of years. It is difficult to estimate what the proportion of good and bad plants actually was, but in one field alone the writer counted as many as five degenerate-type plants to every plant which might have given a fair yield of cotton.

The Government and Ministers

The Government of Southern Rhodesia, which for thirty-three years prior to October 1, 1923, had been in the hands of the British South Africa Company, is now an independent Government. It is administered by the Premier, Sir Charles Coghlan, who is ably supported by the Colonial Secretary [Education], Ministers of Agriculture and Lands, Finance, Law and Defence, Mines and Works.

In my official capacity I have only come into contact with the Minister of Agriculture and Lands, who, at the date of my arrival, was the Honourable W. M. Leggate, C.M.G., succeeded shortly afterwards by the Honourable J. W. Downie, M.L.A.

The Government is keenly interested in the development of cotton in Southern Rhodesia, and from what I can see they are anxious to encourage it in every way possible.

Previous Attempts at Cotton-Growing

For several years past a number of farmers in Southern Rhodesia have been experimenting on a very small scale with cotton, primarily with a view to see if the crop would grow at all, and if so, whether it could be grown at a profit. Those early successes appear to have satisfied farmers that cotton could be successfully grown in normal years, and last year, which was one of record drought, proved that many were able to grow it even in an abnormally dry season.

The present season has gone to the opposite extreme and is the wettest season recorded since information regarding rainfall has been available.

The Staff of the Department of Agriculture has not been sufficient to allow of very extensive cotton investigational work, so that everything remains to be done in the matter of carrying out trials of as many varieties of cotton as possible, in the hope that one will be found specially suitable to Southern Rhodesia. Investigations may be limited by the necessity of fixing on a Jassid-resistant type of cotton, as it was found in the present year that Jassid was one of the chief enemies of the cotton plant.

Agricultural Department

Until June 1924 the Department of Agriculture was under the directorship of Dr. E. A. Nobbs, since when the Secretary, Agricultural Department, has been responsible for its direct administration.

The organization consists of a Chief Agriculturist with two Assistants; a Cotton and Tobacco Division which, at the time of writing, has a Cotton and Tobacco Expert stationed at Bulawayo, and has recently been supplemented by two Tobacco Advisers from the United States; the Dairying, Poultry and Forestry Divisions have each an Expert and an Assistant; the Irrigation Division has in addition to the Chief Engineer, two Assistants; the Weather Bureau, which comes under the charge of the Hydrographic Engineer, deals with rainfall and temperature records, and is responsible for the compilation of meteorological reports. A very useful Journal, which used to be issued bi-monthly, is now issued every month. A Statistical Division is maintained, where statistics of all crops grown are recorded by the Chief Statistician and his Assistant, who are in a position thereby to give reliable crop forecasts. The Chemistry Division consists of the Chief Chemist and two Assistants; the Entomological Division at present has a Chief Entomologist and one Assistant, with an additional Assistant *en route*. At the time of writing the creation of a post of Cotton Entomologist is being contemplated. The Botanical Division has at present but one officer, who, in addition, is Government Mycologist. In addition to the foregoing the Veterinary Department comes under the administration of the Minister of Agriculture and Lands.

Roads

The condition of roads, especially in outlying districts, is not of the best. It is the custom of the country loudly to decry the condition of roads, particularly in the wet weather, but it has to be borne in mind that the country is but young, and even with a most progressive road policy, it will be a considerable time before it can be adequately provided for in this respect. The writer was agreeably surprised to find roads as good as they are. Roughness and unevenness of surface is experienced on practically all roads situated at any distance from the main centres, but so long as progress can be made one has little justification for complaint. What really holds one up

in the wet weather are the numerous "vleis" which are encountered in outlying districts.

It is understood that the present Government are contemplating a progressive road policy in the near future.

Communications

Postal, telegraphic and telephonic communications exist in most parts of the country, and one of the features which agreeably surprised the writer on his arrival in Rhodesia was the extent to which telephonic communication exists between farms which are situated in some instances at considerable distances from the chief centres.

Communication between Salisbury and distant farms is sometimes difficult, as post and telegraphic communication does not extend further than the post offices, to which farmers have to send for their letters and parcels. As telegrams are not despatched from outlying post offices it frequently happens that a letter will reach an outlying farm just as quickly as a telegram.

Railways and Railway Freight

The whole question of railway administration in Southern Rhodesia is at present under investigation by an expert who has been brought out by the Rhodesian Government.

Complaints regarding high freight on Rhodesian railways are common, but considering how new the whole country is, the writer is of opinion that it is fairly well served. This does not mean, however, that there is not considerable room for improvement, and a glance at the map (Vol. II., p. 96), will show that in order to get to any point in Southern Rhodesia from the Union of South Africa, by railway, one has to make a considerable detour.

Varieties of Cotton Grown

The most commonly grown variety in Southern Rhodesia is that known as Improved Bancroft. This variety may have been Improved Bancroft at one time, but in the writer's opinion it is now very mixed. This is no doubt due to the rush for seed of this variety, particularly in the last year, when the cotton-growing industry expanded at such a rate that the demand for seed far outran the supply.

Other varieties grown are Watt's Long Staple, Zululand Hybrid, Griffin, Uganda, Sea Island and an Egyptian variety.

Watt's Long Staple is generally considered to be very susceptible to Jassid and for that reason is not likely to prove a success in this country.

The writer has seen one or two crops of what is known as Zululand Hybrid. Had he not been informed that it was this variety, however, he could not have distinguished it from what is called Improved Bancroft.

Small areas of Griffin and Uganda have also been grown. As regards the latter, the only sample seen by the writer did not appeal to him.

One existing crop, which probably does not extend beyond one-eighth of an acre, consists of Sea Island, grown from seed which had been on exhibition at Wembley. The writer was rather impressed by the way in which this very small crop grew, but it may be that it did better this year on account of the abnormal humidity than it would in a normal year in Southern Rhodesia. In case it should be of interest to Mr. Hamilton, our plant breeder, when he arrives, the grower has been asked to take steps to have this crop isolated and ratooned, with the object of securing pure seed from it for experimental purposes next year. The existing crop was grown right alongside a field of very mixed-looking Improved Bancroft, so that there is little likelihood of the seed being any use for work this year. A sample of the seed cotton, however, has been sent to the writer, and it is interesting to record that it is fully 1½ inches in length, but is not strong. Whether the latter defect is due to the past wet season it is difficult to say, but it is considered worth while to keep this crop, as it appears to have been raised from exceptionally good seed.

The Egyptian crop referred to above has not been seen by the writer, so that little can be said about it beyond merely stating that it is grown from seed which was obtained last year from the Union of South Africa. It is hoped to obtain further information about this crop at a later date.

Gatooma Experimental Farm

A series of experiments were laid out at Gatooma this year in conjunction with the Gatooma municipality. These comprised mostly manuring and spacing tests, with a few varietal lines on one side of the field. The varieties tried were two selections of Improved Bancroft and a selection of Griffin, and one line each of Delphos, Trice, Express and Meade.

The growth of all the plots used for manuring and spacing tests has been such that it is impossible to draw conclusions from them this season. At first the writer was of opinion that the unfavourable season combined with unsuitable soil might have been the cause of failure, because, generally speaking, the growth of all plots was very indifferent, in spite of the fact that they were very carefully attended to. A glance at the varietal lines, however, is sufficient to demonstrate clearly that the fault must have lain with the seed sown, because every one of the varietal lines grew well. It is too early yet to give results of these varieties, but it is hoped to report on them at a later date. As far as appearance goes, the outstanding variety seems to be Delphos, followed closely by Trice and Meade. In the writer's opinion these varieties did well for the reason that they consisted of seed which may be described as reasonably pure.

Seed Supply and Demand

As has been indicated in a previous part of the present report, the seed sown this year is the partial cause of the unsatisfactory yields obtained. If one figures it out the total amount of seed produced in Southern Rhodesia last year was just sufficient to sow the present season's crop, irrespective of whether it was well-matured seed or not. The supply was augmented from the Union of South Africa, but it is a moot point whether the Union was in a better position to supply seed than Southern Rhodesia, owing to the rapid expansion of the cotton-growing industry there.

From what one hears there appears to have been a wild scramble for seed of any kind, which was bought at any price from 3d. to 6d. per lb. This works out at prices ranging from £25 to £50 per ton for seed which, in many cases, was unfit to send to the oil mill, let alone use for planting. Even in the case of farmers who sowed their own seed over again, it is questionable if any guarantee can be given that they received their own seed back from the ginneries in every case. In order to make certain of this point for the ensuing year, the writer has strongly impressed on farmers the desirability of seeing their own cotton go through the ginnery in all cases where they propose using their own seed for sowing, or for sale as reliable seed.

In the course of his official tours the writer has visited a considerable number of cotton crops in the past nine months, and wherever a crop was seen which could be considered good enough for seed purposes, a note was made of it and an offer made to recommend seed from such crops provided the grower undertook to sell it at not more than 3d.

per lb., which price, after many enquiries, Rhodesian farmers appear willing to pay. By letting it be widely known that no seed in the country is worth more than 3d. per lb., and only the best seed worth even as much as that, it is hoped to prevent such excessive prices being charged as were unfortunately rather common last year.

At the Rhodesia Agricultural Union Congress in Bulawayo, in February, it was suggested that Government experts should report upon the best fields of cotton for seed purposes, but the staff at the disposal of the Government has not been sufficient to ensure this being done systematically. The writer has done his best to act up to this suggestion and whenever enquiries for seed come to the Department of Agriculture, a list of growers who have had good crops is supplied, together with other sources which can be relied upon to sell good seed. The procedure has this disadvantage: it has been impossible to visit every crop in the country, with the result that some crops which may be outstandingly good may have been missed. It is not likely, however, that there are many such, otherwise the writer is sure to have heard of them, as Southern Rhodesia farmers with good crops of cotton, especially in such a year as the present, are likely to have let the fact be known.

It is hoped that by sounding a note of warning this year, farmers will pay more strict attention to the sources of their seed supply in the ensuing season. The writer has done his best to bring this to the notice of the public through the medium of the local Press and the *Rhodesia Agricultural Journal.*

If only seed from crops which have yielded well this year is sown, it is felt that one may reasonably expect better results in the coming season.

Agricultural Practices

These are generally on sound lines, and in the course of his visits to farms all over the country, the writer has had very little criticism to offer.

Dates of sowing, distance between rows, and spacing within the row, appear to have been properly carried out in nearly every case. There was a tendency to plant too deeply by such farmers as had not grown the crop previously, but I think sufficient has been said on this question in the course of the season to prevent a recurrence of the practice.

One of the commonest questions which one is asked at farmers' meetings and demonstrations is as to the correct spacing, and the

writer feels that in advising a spacing of 9 to 10 inches one cannot go far wrong. Whatever spacings are ultimately adopted, it is not likely that they will be less or more than 8 to 12 inches, so that by adopting a 9 to 10 inch spacing one cannot be far out.

Another question raised frequently is that of ratooning—a practice which up to the present has not met with much favour. There are a few in the country who are inclined to recommend this practice for high veld conditions and in those areas where rains do not come until late in the season. The writer has endeavoured to point out that in any areas which may now be considered as proved for cotton-growing, such as the Gatooma, Lomagundi and Bindura areas, ratooning should in each case be discouraged. The view has been expressed, however, that there may be a chance of growing cotton on the high veld and late-rain areas if this practice is adopted.

In advising the Government on this question I have pointed out the desirability for the present of leaving districts to decide for themselves whether the practice of ratooning is to be carried out or not. In the event of a decision being arrived at against ratooning the Government should then insist on seeing that such local decisions are strictly adhered to. In this way it is felt that the proved areas mentioned above are not likely to come to any harm, as there is a very strong feeling against ratooning in all three of them. The question is one which was brought up at the Rhodesia Agricultural Union congress at Bulawayo in February and is being brought up again by the same body at their congress to be held in Salisbury in September.

The writer is against the practice of ratooning on principle, for the simple reason that he has never seen a good ratooned crop, though good individual ratooned plants and small patches of ratooned cotton can sometimes be seen. It is felt that a Bill to prohibit ratooning in the whole country might not be adopted by the Government, whereas there is every likelihood of their very strongly supporting local measures to prevent the practice.

Types of Cotton Growers

Among the farmers of Southern Rhodesia one finds all classes, from the dull to the intelligent, and, in some cases, what may be described as the super-intelligent, but all that have been met by the writer are enthusiastic, especially with regard to cotton. They are inclined to be critical of the Government and the Government Depart-

ments, but with it all they are helpful, and out to do all they can to assist. Generally speaking, they are very public-spirited.

Very few of the farmers in Southern Rhodesia have been brought up to farming. One meets ex-soldiers, Government servants, sailors and miners among them, but very few who were born and brought up on farms either in the Colony or elsewhere. Nevertheless, they bring intelligent methods to bear on their practices, and they are at all times willing to accept advice. In the latter respect, perhaps they are too prone to take advice from any source. As regards cotton, it is hoped they will continue on the sound lines that they are following at present, and not be induced to try any fancy methods which they are apt to hear of from a variety of sources. One and all are decidedly hospitable, and the writer records with pleasure his experiences among them.

Ginneries

One of the chief drawbacks to cotton-growing in the past has been the lack of ginning facilities. It would appear that a 40-saw gin was introduced to the country some years ago in co-operation with the British Cotton Growing Association, but that it was not found to work satisfactorily. It is difficult to understand why this should be so, as, generally speaking, there is no known make of ginning machinery which will not gin cotton if properly worked.

It is said that the low prices for cotton were so discouraging that the 1923 crop was sold in Salisbury at 6d. per lb., and used for stuffing furniture, mattresses, cushions, etc. This is also difficult to understand, as the price of cotton since the War at no time has been low enough to justify selling at 6d. per lb. in any part of South Africa.

Last year the Central Ginneries in Salisbury were erected by Major Cooper, D.S.O., to whom credit is due for his enterprise in this direction. It is understood that an acreage of 3,000 was guaranteed, after which he set up what may be regarded as the first commercial ginnery in the country.

The results which were obtained from the sale of cotton last year were such that an increased acreage was put out for the 1924-25 season—an acreage much too great for the Salisbury Ginnery, or so it appeared at the time. Arrangements were accordingly made which led to the formation of three co-operative ginneries, financed by the Government of Southern Rhodesia in conjunction with the British Cotton Growing Association and the Empire Cotton Growing Corporation.

The plant for the three co-operative ginneries was rather late in arriving, and had the season been a successful one, very considerable delay would have occurred in the handling of the crop. As things have happened, however, those three ginneries have been able to cope with the cotton as it came into the ginnery, and in all cases have done satisfactory work.

The *three ginneries* are identical in style and construction. The buildings were designed by the Irrigation Engineer, Mr. A. C. Jennings, in consultation with Mr. Clark of Messrs. Clark and Blackburn, Gatooma, and the same design was used throughout for the three ginneries. They are of unusually sound construction and equipped with five 75-saw gins made by Messrs. Dobson and Barlow. These are provided with pneumatic conveyors and are driven by a Crossley suction gas plant. The presses are of the type made by Messrs. Shaw and Co., and are capable of turning out bales of 500 lbs. with a density of 30 to 32 lbs. to the cubic foot.

It is a matter for regret that the bands for the press boxes at first gave a considerable amount of trouble owing to a fault in the design. Apart from this, they worked satisfactorily, and it is pleasing to record that the first prize for the best bale and lint was awarded at the Salisbury Show to a bale of cotton from the Bindura and District Co-operative Ginnery, Ltd.

At the time of writing (October, 1925), the number of bales produced by the three co-operative ginneries is likely to turn out as under:

	Bales.
Bindura	900
Gatooma	290
Sinoia	200

It is not as yet known what the output of the ginnery at Bulawayo is likely to be. This is the ginnery which is operated by Messrs. Dechow and Tweedale.

Additional ginneries have been erected by Mr. McClelland at Concession, and a small ginnery in the Ayrshire-Sipolilo district is being run by what is known as the Strete Syndicate. The latter, so far, is not equipped with a high density baling press, but this is a matter which may be rectified in the future, as the ginnery is situated in one of the promising cotton districts of Southern Rhodesia.

The position now is that the country is sufficiently well-equipped with ginneries to handle 50,000 bales in the space of three to four

months, and as it is unlikely that the Southern Rhodesia crop will reach this figure for at least another two years, one may take it that the country is now, for the first time, adequately equipped with ginning facilities. If the cotton-growing industry in Southern Rhodesia fails to make progress, the lack of adequate ginning facilities cannot be held to blame as it was in the past.

Cotton and Land Settlement

The question of Land Settlement is at present very much to the fore in Southern Rhodesia. It is one to which the Minister of Agriculture and Lands is devoting close attention.

One of the chief aids to land settlement is, undoubtedly, the development of land for the purpose of growing cotton. This crop appears to attract settlers from the Home Country more than any other.

The British South Africa Company have a scheme of settlement which is fully described in their pamphlets which are issued from time to time. Additional settlement schemes by private companies include that of the Tokwe Ranching Company, near Selukwe, which is based almost entirely on cotton production. At Darwendale there exists a concern which can hardly be considered a settlement scheme, but under which many young men are put on to the land and given a very thorough training in tobacco and cotton culture, together with other crops. The system employed here is one whereby selected men from home and from the Union are employed at a fixed wage, plus a share of the profits of the estates.

Quite recently a company, called the Mining, Ranching, Cotton and Tobacco Lands of Rhodesia, Ltd., has been formed by Sir Abe Bailey. This concern has now as its Agricultural Adviser Mr. H. W. Taylor, who was formerly the Cotton and Tobacco Expert to the Government of Southern Rhodesia, and the loss of whose services has been a great blow to tobacco and cotton growers, in addition to which his wide experience in cotton matters has been of very considerable help to the writer.

Programme of Work for the Ensuing Year

The chief need of the cotton-growing industry in Southern Rhodesia is improvement of the seed supply. There is no means of rectifying matters immediately, but much can be done if farmers will only plant the best seed available, such as it is. This will give

them a cotton which goes fully 1 to 1⅛ inches, but little can be guaranteed in the matter of yield.

It is proposed, therefore, to concentrate on the seed supply question at Gatooma, where it is intended to carry out three main lines of work:—

1. Improvement of existing seed.
2. Investigation of other varieties.
3. Experiments on spacing.

1. *Improvement of Existing Seed.*—The arrangements in hand for the improvement of existing seed are as follows.

The writer has obtained seed from several of the best yielding crops this year. In the first place the seed is being hand-picked to eliminate all naked, semi-naked, and green fuzzed seed. It is proposed to treat the remainder with sulphuric acid to remove all fuzz. This will enable the seed to be screened, so that only the largest and best developed seeds will be planted.

It is hoped that fifty acres can be planted with this treated seed. The growing crop will be carefully observed and rogued as soon as any plants begin to show undesirable characters.

It is not known to what extent rogueing will be necessary, but for purposes of calculation it may be estimated that the remaining plants will give a yield of 500 lbs. seed cotton per acre. Thus we should have $\frac{50 \times 500 \times 2}{3}$ lbs. of improved seed by August 1926. This amounts to over 16,000 lbs. of seed. Reserving 2,000 lbs. for the station's requirements for the following year, there should be about 14,000 lbs. left over for disposal.

Out of 2,500 farmers in Southern Rhodesia we may allow for 1,000 applications for improved seed. The supply would enable the station to supply one thousand 14 lbs. packets of improved seed, which could be distributed to farmers for the express purpose of planting seed plots. Each packet can be labelled with printed instructions to plant wide for rapid propagation. This means that each farmer should have sufficient improved seed to sow a crop of about 50 acres in 1927, which, in turn, should give sufficient seed for the whole country by 1928.

The foregoing presupposes that all goes well and that there will be no hitch of any kind in carrying out the programme outlined. No doubt many difficulties will occur by the way, but a programme has to be framed, and it is up to us to carry it out to the best of our ability.

SEPARATING TABLES ON A COTTON FARM, SOUTH RHODESIA

These tables are made of wire netting of ¹ inch mesh and illustrate the great care which South Rhodesian planters take in cleaning their cotton before sending to the ginnery. The cotton is spread out to dry on these tables, after which it is carefully picked over and any stained, trashy or dirty cotton which may have been picked in the field is removed

2. *Investigation of other Varieties.*—We have on hand the following varieties from the Mississippi Experiment Station—

Delphos—two strains.
Express.
Trico.

From Memphis, Tennessee—

Acala.
Over-the-top.
Tanguis (a Peruvian).

From the Pedigreed Seed Company, Hartsville, S. Carolina, thanks to the President, David R. Coker—

A heavy-yielding selection of Deltatype-Webber.
A selection of Meade imported by the writer.
Several single plant selections.

A cotton received from Mr. Bullock, Native Commissioner, Belingwe, is sufficiently interesting to deserve special mention. Several years ago Mr. Bullock discovered a cotton bush growing at the back of his office, but paid little attention to it at the time. Subsequently new office quarters were built and the old ones levelled to the ground. The cotton plant flourished after the old buildings were removed and Mr. Bullock planted a few seeds in his garden. Cotton from the resulting plants was sent to the writer. It is a fuzzy seeded type with lint of fully 1¼ inches. The same lint was reckoned by a cotton buyer to be 1⅜ inches.

Mr. I. G. Hamilton is bringing several strains with him from Australia, and we are indebted to Mr. F. R. Parnell for a Jassid-resisting cotton, which he has promised to send from Barberton.

Pending the arrival of Mr. Hamilton, I do not consider it advisable to lay down the method which will ultimately be adopted for carrying out variety trials. Sufficient ground should be ready to allow him to multiplicate his tests as often as our supplies of seed will permit.

A point I wish to emphasize is the necessity of propagating a portion of each variety under cages in order to have pure seed to carry out further investigations the following year. This is likely to prove an expensive item, but in the writer's opinion the essential features are to secure and maintain pure strains, to improve the cotton seed supply, and to reckon the cost of doing so afterwards.

3. *Spacing Experiments.*—Sufficient ground should also be available to permit of spacing tests. As in the case of the variety trials I do not propose to discuss this until I have had an opportunity of talking the matter over with Mr. Hamilton.

At the time of writing, the shipping strike has delayed Mr. Hamilton's departure from Sydney. It is not known when he is likely to arrive, but, in the meantime, Mr. Peat will have to do his best.

Owing to unavoidable delays in connection with the leasing of the ground at Gatooma, and other reasons which need not be dealt with here, the writer was only able to commence preparations last August. This means that most of the work at Gatooma has had to be rushed, a condition which does not tend to that state of efficiency which one expects to find on an established plant-breeding station. One has to commence sometime, however, and the state of unpreparedness is merely mentioned by way of warning. Every effort will be made to make the station a success, but it is naturally hoped that criticism of its results may be suspended until the station has been in existence for at least one season.

Whatever difficulties may arise, it is confidently hoped that much useful information will be obtained by the functioning of the station in the forthcoming season.

Itinerant Work in the Districts

I have been kept on the road fairly steadily ever since I arrived in the country. I am the first to admit, with a certain amount of regret, that a considerable part of my time was wasted by not organizing my tours better. This is a matter which I hope to rectify in future by attending only to calls and invitations from Farmers' Associations. During the first few months of my service in Southern Rhodesia I accepted invitations to visit individual farmers indiscriminately, with the result that, as the season progressed, I found myself tied by previous promises to individuals and could not give as much time as I should have liked to Farmers' Associations.

By the end of the season, however, I find that only one request from a Farmers' Association has not been complied with, and perhaps six or seven individual farmers to whom I promised visits which subsequently I was unable to make. They will come first on my list for the oncoming season, but once they are fulfilled I shall have to make a point of meeting farmers through their Associations only.

As there has been no Government Cotton Expert at Headquarters since July, the work has fallen on my shoulders, but such service as

I have been able to give has been a pleasure. The appeals for advice that come from distant farms have to be answered as promptly and fully as possible.

Apart from routine correspondence, a considerable amount of time has to be given to visitors. The callers are farmers who have come a long way to seek out their information in person. As such they deserve every consideration, and the writer endeavours to give them his best attention. Yet unfortunately it is sometimes difficult to devote as much time to such interviews as one would wish, since on return from tour there is much delayed correspondence to deal with.

Additional work is entailed in reporting on numerous samples of cotton which are sent in for report. In the event of a cotton grader being appointed by the Government he would relieve the writer of this. The question of appointing a Government Grader is one which is very much to the fore at the present time, as farmers declare they do not know the value of the commodity they are selling. In the writer's opinion the farmers appear to have had a better idea, in some cases, of what they were selling, than the buyers had of their purchases. The fact remains, however, that the appointment of a Government Cotton Grader is a necessity once the cotton crop is sufficiently large to justify the creation of such a post.

It is, at present, the writer's intention to recommend the appointment of a grader as soon as the possibility of a 10,000 bale crop is in sight. It is hoped that the 1925-26 season will realize such a crop.

The writer's services were in demand in the capacity of judge at several of the leading Agricultural Shows in the Colony. This is one of the most pleasant and instructive duties one has to perform. In addition to seeing the best the country can produce in the way of cotton, one has an opportunity of discussing various points with the other judges. It was the writer's privilege to act in the foregoing capacity in the company of Mr. H. W. Taylor, formerly Cotton and Tobacco Expert to the Government of Southern Rhodesia, and Mr. W. H. Scherffius, ex-Chief of the Tobacco and Cotton Division in the Union of South Africa.

Any recent note on cotton in Southern Rhodesia would be incomplete without reference, also, to the activity of Mr. D. D. Brown, Assistant Tobacco and Cotton Expert. Mr. Brown had to act for Mr. Taylor while the latter was absent on duty at Wembley. His energy while so acting has been commented on frequently by numbers of farmers who have mentioned him to the writer.

CONCLUSION

The cotton-growing industry has come to stay in Southern Rhodesia. It has to be very distinctly borne in mind, however, that it is yet in the initial stages. Many mistakes and numerous pitfalls lie n the way before the crop is firmly established on a sound basis. The Government has a number of problems to tackle, not the least of which are the questions of ratooning, and the formation of Ordinances governing the operations of ginneries. The writer, and the additional staff granted by the Empire Cotton Growing Corporation, have much uphill work in establishing a supply of the right type of cotton seed. Lastly, and most important of all, the farmers of Southern Rhodesia are advised not to allow themselves to be carried away by temporary reverses or successes.

The writer feels confident that the Government is anxious to do all in its power to foster cotton growing. Assurances to this effect have been vouchsafed him by the Governor, the Premier and prominent members of the Cabinet. The Minister of Agriculture has given practical demonstration that he is doing all he can to advance the industry, and is both willing and anxious to be guided by responsible bodies such as the Empire Cotton Growing Corporation and the British Cotton Growing Association. The growers have already demonstrated their enthusiasm, which continues unabated despite a year which has been most disappointing.

How rapid may be the development of the industry which it is hoped will reward our united efforts, can naturally not be foretold, but that the final outcome will be fruitful, and of benefit to the robust, intensely British, Rhodesian farmers, among whom it has been such a pleasure to work, is the earnest desire of the writer and his staff.

COTTON-GROWING STATISTICS—VII

COMPILED BY

JOHN A. TODD

THIS series of statistics has now been running ever since the first issue of the Journal, that is, for a period of fully two years, and we have now pretty well covered the ground, having dealt not only with the world's principal crops, but also with consumption, stocks, and prices.

For the future, the intention is to continue the statistics from time to time, revising them whenever required and keeping them always up to date. At the same time, it is hoped to introduce a series of diagrams embodying the most interesting of the statistics, and of these one, of the World's Monthly Carryover of American Cotton, has already been given in the issue of January, 1926.

In this issue we propose to revise the original table of the world's crops, and also those of the Indian, Egyptian, and Smaller Crops. In the case of the China crop in Table I. the opportunity has been taken to revise the figures throughout. In the first half of the table, especially in the years just before the war, semi-official reports had been published which made the total of the Chinese crop as high as four and five million bales; but these were afterwards completely discredited, and the fact that the same large figure had been repeated by certain sources not really independent had resulted in our average figure being unduly raised for certain years. By omitting these duplicates the figures have been brought down to a better comparable basis; but even with this the sudden rise of the China crop from 1909 to 1910 is almost certainly fictitious.

The figures in Table I. become much more interesting when embodied in a diagram which is given on p. 167. The first point brought out by this diagram is the obvious domination of the world's total by the American crop. It will be seen, however, on closer examination, that the correlation between the American crop and the total is strengthened by the fact that, on the whole, the general tendency of the Indian, Egyptian, and other crops has throughout been fairly similar to that of the world's total and the American, the reason being that the supply of American pretty well controls the world price, which reacts on the supplies of all other crops, as well as the American. There are, however, occasional years in which there is a marked discrepancy between the movement of the American crop and that of the world's total—*e.g.*, in 1919, when a very large Indian crop more than outweighed a small American crop. On this

point it should be noted that the Government estimate of the Indian crop for 1925, which was almost the only crop in the world to show a decline that year, is regarded in trade circles as much too low, but that, of course, is almost normal (hence our inclusion of the Indian crop in 400-lb. bales, along with all the others in 500-lb. bales).

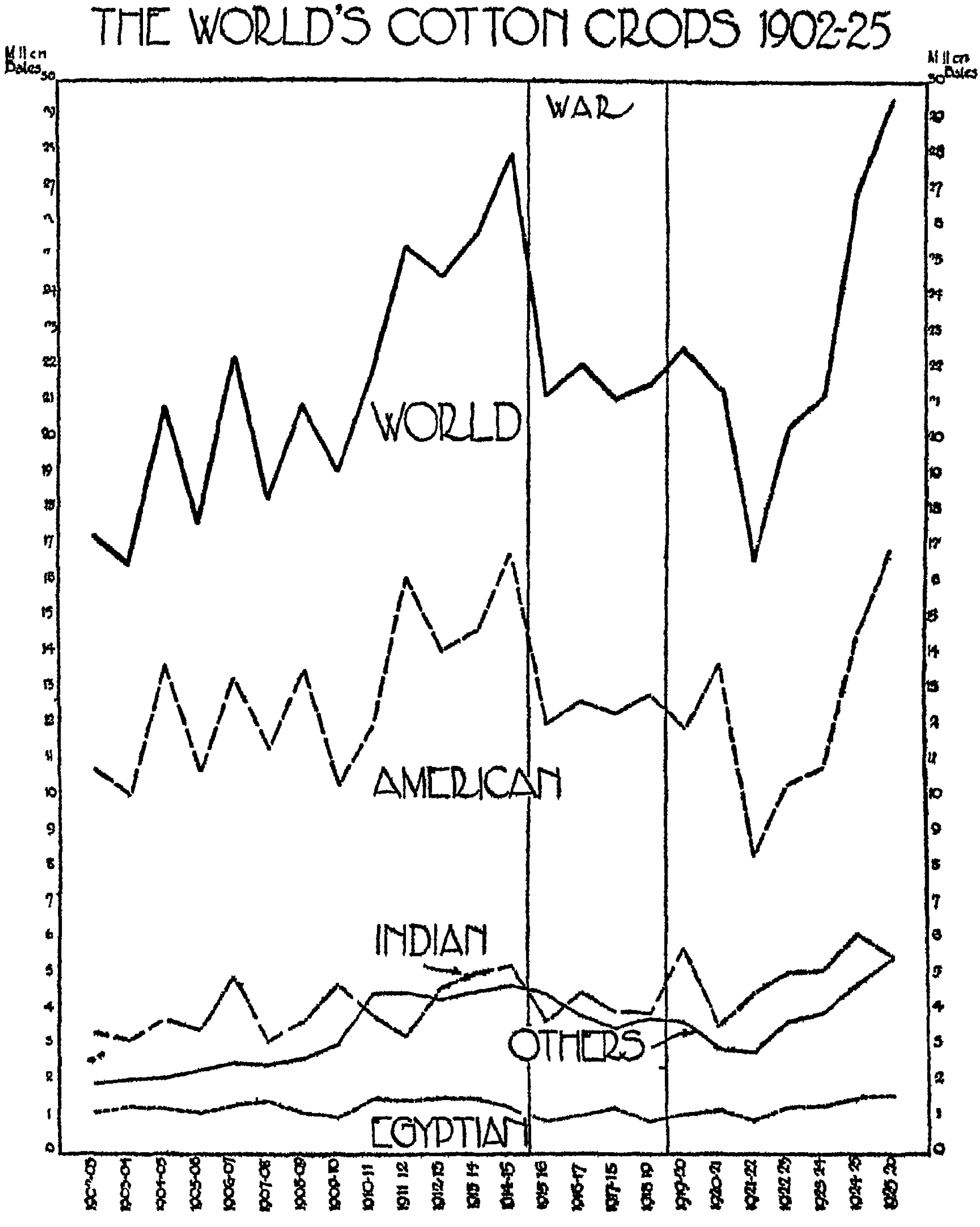
The main point of interest, however, in this diagram is the wonderful recovery since 1921; owing to the comparatively huge American crop of 1925 that year's total is now certain to beat the record of 1914. One cannot help being struck by the fact that this steady rise for four years in succession is unique in the diagram.

TABLE I.—THE WORLD'S COTTON CROPS, 1902–1925.

Bales of 500 lbs. (approximately). 000's Omitted. Linters included in American Crop. Estimates in italic figures.

	America	*Per Cent of World Total.*	*India**	*Egypt.*	*Russia.*	*China.*	*Others.*	*Total.*	*Per Cent. on 1914.*
1902–03	10,784	62	3,367	1,168	342	800	801	17,262	62
1903–04	10,016	61	3,161	1,302	477	800	751	16,507	60
1904–05	13,697	66	3,791	1,263	536	756	803	20,846	75
1905–06	10,726	61	3,416	1,192	604	788	938	17,664	63
1906–07	13,305	60	4,934	1,390	759	806	1,027	22,221	80
1907–08	11,326	62	3,122	1,447	664	875	950	18,384	66
1908–09	13,432	64	3,692	1,150	685	1,000	971	20,930	75
1909–10	10,386	54	4,719	1,000	663	1,419	950	19,137	69
1910–11	11,966	55	3,889	1,515	879	2,589	968	21,806	78
1911–12	16,109	64	3,288	1,485	859	2,552	1,058	25,351	91
1912–13	14,091	57	4,610	1,507	883	2,298	1,160	24,549	88
1913–14	14,614	57	5,066	1,537	980	2,303	1,287	25,787	92
Pre-War Averages		60							75
1914–15	16,738	60	5,209	1,298	1,157	2,363	1,154	27,919	100
1915–16	12,013	57	3,738	961	1,402	2,057	984	21,155	76
1916–17	12,664	57	4,489	1,022	1,105	1,714	1,027	22,021	79
1917–18	12,345	58	4,000	1,262	603	1,836	1,086	21,132	76
1918–19	12,817	59	3,972	964	420	2,084	1,296	21,553	77
1919–20	11,921	53	5,796	1,114	246	1,968	1,483	22,528	81
1920–21	13,700	64	3,600	1,206	116	1,373	1,471	21,466	77
1921–22	8,360	50	4,485	972	52	1,364	1,440	16,673	60
1922–23	10,320	51	5,073	1,243	52	2,022	1,603	20,313	73
1923–24	10,811	51	5,162	1,306	295	1,785	1,871	21,230	76
1924–25	14,497	54	6,141	1,455	450	1,976	2,325	26,844	96
1925–26	*16,900*	*57*	*5,569*	*1,600*	*927*	*2,068*	*2,500*	*29,564*	*106*
Post-war Averages		56							80

* 400-lb. bales.



"Others" includes Russia and China and smaller crops

For the Indian, Egyptian, and Smaller Crops it has not been thought necessary to repeat the whole of the original table. They have therefore been carried back only to 1914 in each case. In the Egyptian crop table the Government figures have been taken for acreage throughout, though the trade opinion is that the actual acreages since 1923 have been distinctly larger. The apparent recovery of the yield per acre in the last three years is therefore dubious.

TABLE II.—INDIAN CROP, AREA, YIELD, AND PRICE, 1914–1925.

Seasons	*Area (Acres).* 000's.	*Crop (Bales of 400 Lbs.).* 000's.	*Yield per Acre. (Lbs.)*	*Net Exports and Consumption.* 000's.	*Season's Average Prices*	
					No 1 Good Oomra.	*Per Cent. on American.*
1914–15	24,595	5,209	85	4,889	4·19	80
1915–16	17,746	3,738	84	5,109	5·79	77
1916–17	21,745	4,489	83	4,985	9·02	80
1917–18	25,188	4,000	64	4,499	16·10	74
1918–19	20,997	3,972	76	3,991	17·15	87
1919–20	23,352	5,796	99	5,343	18·05	71
1920–21	21,340	3,600	67	4,941	8·21	69
1921–22	18,451	4,485	97	5,972	8·72	77
1922–23	21,804	5,073	93	6,270	10·25	69
1923–24	23,636	5,162	87	5,979	12·37	70
1924–25	26,461	6,141	99	—	11·04	80
1925–26	*26,305**	*5,569*	*85*	—	—	—

* Third forecast against 24,833 at same date last year.

TABLE III.—EGYPTIAN AREA, CROP, YIELD, AND PRICE, 1914–1925.

Season.	*Area Feddans.* 000's.	*Crop Kantars.* 000's.	*Average Yield Per Feddan. (Lbs.)*	*Season's Average Prices.*	
				F. G. F. Brown. Pence Per Lb.	*Premium over American Middling. Per Cent.*
1914–15 ..	1,755	6,490	3·70	7·34	40
1915–16 ..	1,186	4,806	4·06	10·42	39
1916–17 ..	1,656	5,111	3·10	21·56	75
				Sakel.	
1917–18 ..	1,677	6,308	3·75	30·97	43
1918–19 ..	1,316	4,821	3·66	27·85	41
1919–20 ..	1,574	5,572	3·54	60·34	139
1920–21 ..	1,828	6,030	3·30	30·24	154
1921–22 ..	1,292	4,858	3·76	19·75	74
1922–23 ..	1,801	6,213	3·45	17·29	16
1923–24 ..	1,715	6,531	3·81	21·55	22
1924–25 ..	1,788	7,274	4·07	29·82	116
1925–26 ..	1,924	*8,000*	*4·15*	—	—

TABLE IV.—SUMMARY OF THE SMALLER CROPS, 1914–1925.

In 500-lb. Bales (approximately). 000's Omitted

	1914.	1915.	1916	1917.	1918.	1919.	1920.	1921.	1922.	1923	1924.	1925.
Persia	131	127	91	72	66	84	118	87	105	*110*	*110*	*110*
Europe and Asia Minor	153	126	132	119	109	128	120	56	76	85	316	*320*
Mexico	112	100	106	110	237	203	211	155	151	159	239	*240*
Brazil	406	296	341	413	486	552	453	570	571	631	*650*	*750*
Peru	123	115	128	130	136	183	160	192	179	237	*250*	*250*
Other South American	14	13	13	19	21	20	38	61	71	121	148	*200*
West Indies (British)	5	4	3	2	5	5	4	3	5	*5*	*5*	*5*
West Indies (Others)	13	15	11	11	12	16	13	22	20	*20*	*20*	*20*
East Indies, etc. ..	71	69	77	73	68	90	76	76	73	*75*	*75*	*80*
Japan and Korea ..	68	63	63	79	92	118	141	120	206	219	*220*	*200*
Africa (British) ..	55	53	55	53	58	72	126	83	122	183	254	*280*
Africa (Others) ..	3	4	7	5	6	12	10	13	16	*16*	*16*	*20*
Australia and Iraq ..	—	—	—	—	—	—	1	2	8	10	22	*25*
Totals ..	1,154	985	1,027	1,086	1,296	1,483	1,471	1,440	1,603	1,871	2,325	*2,500*

Estimates in italic figures.

NOTES ON CURRENT LITERATURE

COTTON IN INDIA.

177. We have received the following Report: *Scientific Reports of the Agricultural Research Institute, Pusa,* 1924-25.

178. CHARACTERISTICS OF INDIAN COTTONS. A useful summary of these is to be found in the *Bombay Cotton Annual,* 1924-25, on p. 37.

179. EAST INDIAN COTTON: UNSATISFACTORY GINNING OF SIND AND BENGAL COTTONS. By Arno S. Pearse. (Abstr. from *Int. Cott. Bull.,* vol. iv., 2, No. 14, 1926, p. 215.) Dealing with the complaints about the presence of seed cotton in the bales.

180. BOMBAY: NEW COTTON EXCHANGE. (Abstr. from *Int. Cott. Bull.,* vol. iv., 2, No. 14, 1926, p. 224.) The new Cotton Exchange has been opened by the Governor of Bombay, Sir Leslie Wilson. The buildings cost more than 18 lakhs of rupees, and contain 120 buyers' and 80 sellers' rooms. The arbitration, or survey room, is capable of handling 300 to 350 arbitrations per hour. The trading hall has been constructed on the principle of the New York and Liverpool forward markets; three rings have been provided, the centre, or Broach ring, being upon the lines of that in New York, while the two smaller Oomra and Bengal rings are similar to the Egyptian and Empire contract rings in Liverpool.

COTTON IN THE EMPIRE (EXCLUDING INDIA).

181. The following Reports have recently been received:

Barbados. "Annual Report of Dept. of Agr., 1924-25."
Malta. "Annual Report for 1924-25."
South Africa. "Annual Report of Dept. of Agr., June, 1925."
St. Vincent. "Annual Report of Dept. of Agr., 1924."
Swaziland. "Annual General Report for 1924."

182. EUROPE: CYPRUS. *The Cyprus Agr. Journ.,* October, 1925, reports attacks of aphis, caterpillar, etc., and states that the cotton crop is likely to be affected by the shortage of water. The boll worm is not so bad as last year.

183. MALTA From the *Report Supt. of Agr.* for 1924-25, recently received, we quote the following: "This year's good rainfall and the ample moisture accumulated in the soil has induced many farmers, soon after harvesting the sulla and other forage, to proceed at once to work the land for a summer catch crop of cotton, so that it is hoped that this year's crop of cotton will also be a good one. Cotton under irrigation is being grown on a small scale in the West District, but the farmers are slow to take up this ready means to turn to better advantage some of the irrigated land now devoted to vegetables.

"At the Experiment Farm an area of a little over half an acre was again sown with Upland long-stapled cotton, but as in the past two years, owing to the unsuitable nature of the soil, along with the shortage of rain in the spring of 1924, the crop has not proved as satisfactory as it would have been under better conditions. However, this sort of cotton is now beginning to be grown on a limited scale at Zebbug and Fiddien, and in several places in Gozo, and is well spoken of by the farmers, who are finding it more productive than the ancient local sort,

and just as early, with a longer and whiter fibre, although slightly lighter in weight. It is accordingly being sought after by the dealers, but the quantities as yet available are not such as to command an appreciable rise in price. The cultivation of the so-called Calabria or Gallipoli cotton, which, like the Upland cotton, is another form of *Gossypium barbadense*, has rapidly extended in both islands during the last few years, at first owing to the greater power of the resistance of the plants against root rot, which, especially on clayey and imperfectly drained soil, is so injurious to our typical ancient Maltese cotton plant. As the quality of the fibre of the Gallipoli cotton is better than that of the Maltese cotton. and the production about just as good, the change is all to the better, and in the long run the price will be more remunerative than that formerly offered."

184. ASIA: IRAQ. *The Economics of Rice and Cotton Cultivation in the Dialahliwah.* By Khan Sahib A. A. Soofee. (*Mem.* 10, *Dept. Agr.*, May, 1925.) The value of the cotton crop in the experiment was two and a half times that of the rice for the same area, while it only used about a quarter of the water required by the latter.

185. AFRICA. *Cotton Planting in British Central Africa.* By Captain S. Davis. (Abstr. from the *Farmers' Journ.*, Nairobi, vii., **49**, 1925, p. 17.) In this article the author states that "though it may be a fallacy to proclaim prematurely the potentialities of a new country, it is, however, no exaggeration to say that, given more good roads and a through railway connection between Beira and Lake Nyasa, also materialization of the projected bridge over the Zambesi River, the possibilities of the development and expansion of the cotton industry in British Central Africa are vast and incalculable, for in the lake regions and other low-lying areas, are many millions of acres of fertile land admirably suited to the cultivation of cotton and other fibrous crops. There are at present, however, many adverse factors for the planter to contend with, such as climatic difficulties, pests, labour troubles, destruction of crops by local fauna, etc., but with the advance of civilization most of these difficulties are bound to disappear gradually; for instance, the clearing of forest land and unrestricted shooting of game would automatically eliminate the tsetse-fly nuisance, the draining and oiling of swamps would greatly reduce the danger of malaria and blackwater fever, and intensive cultivation combined with careful seed selection would undoubtedly greatly increase the output of cotton per acre."

The greatest enemies of the planter are the pests, which include boll worms (both the red and the pink variety), cotton aphis, cut worm, boll maggot, boll rot, cotton stainer, white ants, root-gall caterpillars, locusts, etc.

186. RHODESIA (SOUTHERN). We have received from the High Commissioner a copy of a *Review of Agricultural Conditions in Southern Rhodesia to Dec.* 31, 1925, by W. E. Meade, from which we quote the following: "On the whole, throughout the Colony the planting season has been a late one, and crops are not as well advanced as is usually the case at this date. While this will not necessarily adversely affect farmers at altitudes round about 4,000 feet, it may tend to reduce the yields on the high veld, more particularly if the season should prove to be a short one. In such areas the prospects for the cotton crop are not favourable, but, on the other hand, in the better recognized cotton-growing districts the outlook is satisfactory. Replanting of cotton has, in certain instances, been necessary."

187. SOUTH AFRICA. From the *Ann. Rept. of the Agr. Dept.*, June, 1925, recently received, we quote the following: "The phenomenal interest in cotton culture continues, and large stretches of ground are being cleared and prepared for the 1925-26 crop, so that if anything like a favourable season is experienced, and the ravages of insect trouble can to some extent be overcome, a production of 30,000 bales of lint may be expected.

"The assistance of the officers of the Empire Cotton Growing Corporation has meant a great deal to the Department in the investigational work at present under way. The comprehensive range of experimental and investigational work at the experiment stations was continued this season, a special feature, and one likely to prove of great importance to the industry, being the propagation of jassid-resistant cotton.

"It has been decided to lay out eighteen series (sixty plots each) of fertilizer plots in different parts of the cotton belt to study the fertilizer requirements of the crop, and to continue them for a period of at least four or five years. No such comprehensive fertilizer experiments with any crop have yet been undertaken, and the results should furnish a basis for the fertilizer requirements of this crop throughout the cotton area of South Africa.

"Excellent work in grading has been done, and the adoption by the Department of a rigid system of cotton grading under regulation has contributed greatly to the excellent reputation South African cotton enjoys overseas."

The Report also states that the alarming spread of cotton pests has necessitated a decision to engage two more entomologists from oversea, in addition to the two supplied by the Corporation, and to keep these four men and the senior entomologist entirely to the work on cotton pests in order to devise measures of control. The locust invasion also was severe during the season, and the senior officers were called together to exchange experiences and to make suggestions regarding the future work.

188. *Helping the Industry Along.* (Extracted from *South Afr. Cott. Growers' Journ.*, vol. ii., 6, 1926, p. 35.) "The example of the Union Castle Mail Steamship Company, Ltd., can well be followed by those in a position to give the cotton-growing industry in these parts a measure of tangible support. The Union Castle Steamship Company has placed an order valued at £10,000 with a Manchester firm for 20,000 sheets and 20,000 pillow cases for the new mail motor vessel and an intermediate steamer, with the stipulation that the articles are manufactured from cotton grown in the Union."

189. *A Visit to the Candover Estates.* (*S. Afr. Cott. Growers' Journ.*, 2, November, 1925, p. 11.) On these estates, 8,000 acres are under cotton and 6,000 in preparation, while 67 white men and over 3,000 natives are employed.

190. *The Afr. Cott. Journ.*, i., 19, 1925, p. 9, states that the crop in the Pietersburg district has only been 2,500 bales against the 12,000 hoped for. Drought and frost appear to have been chiefly responsible. Mr. N. J. Smit contributes an article on the soils in the Zoutpansberg district.

191. It is stated in the *Annual Report, Swaziland*, for 1924, a copy of which has recently been received, that approximately 8,000 acres were placed under cotton during the year. Mr. Milligan visited Swaziland in July, and was very much impressed with the cotton-growing prospects of the Territory. The varieties of cotton grown are "Griffin," "Watts Long Staple," "Improved Bancroft," and "Zululand Hybrid." The main crop is "Griffin," which, with proper selection and acclimatization, is giving excellent results. "Improved Bancroft" is also largely grown, as it appears more resistant to jassid attack on account of the hairy condition of the leaves. Of the total crop, 83 per cent. was graded $1\frac{1}{8}$ inches and over.

Many swarms of flying locusts invaded the country from the Union, and it was expected that breeding on a large scale would occur, but for some unaccountable reason this did not happen, and hatchings were reported from two parts only. These young swarms were destroyed. Supplies of poison and spray pumps to deal with the young locusts are distributed throughout the Territory.

192. SUDAN. On the occasion of the official opening of the Makwar Dam, *The Near East and India* published a Sudan Supplement containing, among others, two very interesting articles entitled "The Makwar Dam: What it Means to the Sudan," and "The Sudan's Part in Empire Cotton Production." Perusal of the former article enables one to form some idea of the scope and magnitude of the Makwar Dam and Gezira irrigation scheme, and of the serious difficulties that had to be overcome before the result was achieved which constituted an immense triumph for British engineering. The second article contains an interesting account of the work of the Sudan Plantations Syndicate since its inception; descriptions are also given of the types of cotton grown, and of the methods of cultivation employed.

193. TANGANYIKA. *Tanganyika's Cotton.* We have received from the Director of Agriculture a report on the 1925 cotton season, from which we quote the following: "A crop of about 8,000,000 lbs. of lint, or approximately 20,000 bales, is expected this year. The return, about the same as that of the previous season (7,500,000 lbs), is disappointing, particularly in view of the circumstance that the distribution of cotton seed to natives had been increased from 1,047 to 1,594 tons. It is possible that this estimate even may not be reached, as natives will be discouraged from picking their cotton by the fall of local prices in sympathy with that in the world's markets.

"As is well known in the Territory, this reduced yield is due to the very unfavourable season that was experienced—a season that has left its mark on the figures of export of the produce of all annual crops in the country, and caused a shortage of food crops in some districts that necessitated the forbidding by Government of exports of such produce. In many areas, particularly Kimamba and Morogoro, the cotton responded to the adverse conditions by partial failure to continue the normal growth of the half-formed bolls, which exhibited signs of internal boll rot, a phenomenon that is being investigated with the aid of the Bacteriological Laboratory of the Medical Department. In another area, Rufiji, the loss was increased by rats, which in large numbers dragged the seed cotton out of the ripe bolls, nibbled the seed, and spoiled the lint. In Lindi, attacks of plant lice (green bug, aphis) near the beginning of harvest reduced the strength of the already handicapped cotton, but there was improvement later.

"It is regrettable to have to state that the condition has been made worse through the general neglect of planters and growers to sow their seed early, and in many cases also through the insufficient preparation of the ground for the seed (caused in some instances, it is admitted, by the difficulty of obtaining labour adequate for the purpose). This late planting of cotton is a serious matter in the Territory. It needs the most active attention by all planters of cotton, who must make up their minds to get their land ready early, and sow their seed in good time, keeping a reserve for any necessary later plantings. It is best to sow cotton seed when the rains are expected, not to wait until the rains have come.

"Nevertheless, the picture is not all one of gloom. This has been a severe testing season for cotton, which has come through it in an encouraging way. It has suffered, generally, less than any of the food crops, even where its cultivation was perfunctory or neglected, and has shown itself to possess the quality of dependence as a cash crop in greater measure than the only other annual native cash crop of similar importance—the groundnut. Cotton has given the native farmer cash to buy the food that the grudging season did not yield for him, or that his improvidence caused him to sell prematurely; it has also paid his tax."

194. UGANDA. *Railways in Uganda.* (Abstr. from *Uganda Herald*, November 20, 1925, p. 13.) The Government Committee on Railway Extension in Uganda have stated, in their preliminary report, that the most urgent problem to be settled

is the linking up of Kampala with the main-line system, and suggest that the best route would be from Kampala to Jinja, and direct thence via Iganga to join the present extension near Busambatia. The reasons given for suggesting this route are: (1) That Kampala is the commercial capital of the country, and it is estimated that there is a population of 30,000 within five miles of Kampala Railway Station. Developments are being made in all directions, but every industry is hampered owing to the lack of railway facilities. The food and fuel supplies necessary for such a large population are on an increasing scale. Internal transport costs are high, and railway communications are essential to provide food at a reasonable rate and keep down the cost of living. (2) That Jinja is the second largest town in the country, with an important and growing trade. It is the headquarters of many business firms trading in the Eastern Provinces. A great volume of traffic already exists across the Nile at this point, in spite of the present disabilities, and this will rapidly develop. The town possesses many natural advantages, and there is ample room for extension and development. The Ripon Falls can provide ample power for all purposes, and the water supply is excellent and unlimited. There is a good port which might be developed to become the headquarters of the Uganda Railway Marine; in fact, all the surroundings are suitable to the requirements of a busy commercial port.

From the latest report received from the Department of Agriculture, we quote the following with reference to the question of transport: "During the 1925 season no difficulty was experienced in moving the cotton crop to Lake ports and stations, and ample road transport was available in all areas. Much difficulty was, however, again experienced in clearing consignments from receiving stations on the railway system. This was mainly due to congestion at 'bottle-neck' ports, and the cotton was subject to delays and exposure to weather at various points. Extra facilities have been provided at ports and stations for the handling of the forthcoming crop, and in order to speed up the movement of baled cotton the arrangements notified in Bulletin No. 3, 1925-26 (*Cf.* Abstr. 41), came into operation on January 1st."

Heavy rains have been experienced in many districts, but the prospects of the crop continue good throughout the Protectorate.

195. AUSTRALIA: QUEENSLAND. *Cotton Values.* (*Queensl. Agr. Journ.*, xxiv., 4, 1925, p. 391.) Giving the prices to be paid by the Government for various qualities of cotton. Payment is now to be made on length of staple as well as on grade; thus the best grade will receive 3½d. if the staple be not over 1 inch; 4½d. if between 1 inch and 1⅛ inches; and 5d. if over the latter. These prices also hold in New South Wales.

196. WEST INDIES: BARBADOS. From the *Report on the Agr. Dept.*, 1924-25, we quote the following: "The experiments for improving the quality and increasing the yield of lint of the varieties of Sea Island cotton grown in the island were continued during the year under review. The usual procedure adopted in attempting to improve the native variety of cotton was continued, with satisfactory results.

"It is very regrettable that the pink boll worm (*Pectinophora gossypiella*, Busck) is now to be found in almost all the cotton-growing districts of the island. An effort was made to control the spread of this pest by the passing of an Act to amend the Cotton Diseases Prevention Act, 1919. The chief feature of the new Act is that on or before the last day previous to the beginning of the close season every occupier must dig up and effectually destroy by fire in the field all cotton plants and stumps and any refuse cotton that remain growing or planted on land in his occupation, and must destroy any cotton plant or part thereof stored in any building, the ginneries being, however, exempted from the latter provisions.

"In several districts considerable injury was caused to the cotton plants by the cotton worm (*Alabama argillacea*). The spread of this pest should be kept in check by efficient dusting with Paris green."

197. St. Vincent In the *Report of the Agr. Dept.* for 1924, recently received, an interesting description of the research work in progress is given by Mr. L. H Burd under the following heads: "The Pure Strains of Sea Island Cotton," "Spacing Experiment," "Plant Development and Crop Analysis," "Lateral Root Development," "Genetics," "Work of the Sorter," "Cytology."

The Report also contains descriptions of the manurial experiments with Sea Island and Marie Galante cottons (pp. 4 and 26); the work of seed selection (pp. 14-16); the work done in connection with the control of the major pests of cotton—*i e.*, pink boll worm, cotton stainers, and cotton worm (pp. 16-20); the minor cotton pests and diseases (pp. 23-24) In addition, accounts are given of the progress in the cotton industry (pp. 27-30) and of the working of the Government cotton ginnery (p. 45).

COTTON IN THE UNITED STATES.

198. American Cotton Industry. By F. Nasmith. (*Text. Recorder*, vol. xliii., **514**, 1926, p. 81.) This paper deals in a very readable way with the cotton industry of the U.S.A. from cultivation to distribution of the finished article. The products of the American mills being almost entirely consumed in the country, mass production, with its concomitant lack of variety, is the keynote. Many interesting sections occur—*e.g.*, the statement of areas cultivated and yields and prices obtained (on p. 81), the description of aeroplane dusting for weevil and the map of available country for extension of cultivation (on p. 82), and the account of the growing mill industry of the South (on p. 84). In conclusion, the author states that "the United States cotton manufacturing industry is one of considerable magnitude. Its activities are growing, particularly in the Southern States; it is not yet a world force in the export trade, having such a considerable home market to feed; it does not produce as fine quality goods as this country, but is developing in this direction; count for count of yarn, the United States mills will use a better stock of cotton than we will; the operatives of the North-East are mixed, those of the South, although requiring training, are of good class; the takings of the American mills are increasing, and if there is any lesson from this lecture it is to assist Empire-grown cotton whenever possible."

199. Field Crops Work at the Raymond, Miss., Substation, 1923 and 1924. By C. B. Anders. (*Mississippi Sta. Bull.*, 224, 1924, pp. 3-12. Abstr. in *Exp. Sta. Rec.*, 53, **4**, 1925, p. 332.)

COTTON IN EGYPT.

200. The Effect of the Summer Fallow upon Soil Protozoa in Egypt. By E. McKenzie Taylor and A. C. Burns. (*Bull. No.* 52, *Tech. and Sci. Service.* Govt. Publications Office, Ministry of Finance, Dawawin P.O., Cairo. Price P.T. 5.)

201. The Lake Plateau Basin of the Nile. By H. E. Hurst. (*Physical Dept. Paper, No.* 21. Govt. Publications Office, Ministry of Finance, Dawawin P.O., Cairo. Price P.T. 10.)

COTTON IN FOREIGN COUNTRIES.

202. We have received from the Department of Overseas Trade a copy of the *Report on the Commercial, Industrial, and Economic Situation in China*, June, 1925, by H. J. Brett, and of the *Economic and Financial Conditions in Paraguay*, dated September 1925, by Frederick W. Paris. Also from the Association Cotonniere Coloniale a copy of *Bulletin No.* 73.

CULTIVATION AND MACHINERY: IRRIGATION, ETC.

203. COTTON CULTIVATION, CALIFORNIA. By O. F. Cook. (*Journ. Heredity*, 1925, 16. Abstr. from *Summ. of Curr. Lit.*, v., 20, 1925, E. 102.) The advantages of community production are now so well recognized that legal protection is being given to one-variety communities against the danger of mixture and impairment of seed stocks. Acala cotton is the variety selected for community growth. A second law provides for the certification of pure cotton seed by the Californian Department of Agriculture.

204. SEGREGATED COTTON GROWING. (Abstr. from *Queensland Agr. Journ.*, xxiv., 4, 1925, p 392.) "The subjoined extract from the *New York Journal of Commerce* of recent date shows how seriously the United States Department of Agriculture considers the necessity of growing 'community basis' cotton, and emphasizes the advantage that Queensland has gained by starting off on such a basis. Differences in conditions governing the cotton industry in the United States and Australia must, however, be borne in mind when considering any relationship of the American plan to our own particular cotton interests. There, of course, the industry is firmly established in several States, and the Cotton Belt covers enormous territory with immense crop acreages.

"WASHINGTON.

"A programme of activity with the States looking to the adoption of a single variety of cotton in each of the cotton-growing communities of the South, is being mapped out by the Bureau of Agricultural Economics of the Department of Agriculture. This calls for a study at the outset, in co-operation with the various State institutions and extension services, of production in the States, and to this end it is planned that six communities in each State undertake the assembling of 1,000 samples of cotton representative of the crop that passed through each such market during the season.

"Each of the samples will be marked as to variety, date of sale, price, and buyer's description. In each State the samples will be assembled at a central point, and classed by representatives of the New Orleans Board of Cotton Examiners. Department of Agriculture officials declare that from these samples and data accompanying them it will be possible to obtain a great deal of information which may later be used in a campaign to extend production of cotton on a community basis, and to show the advisability of each community adopting a single superior variety of cotton, and delaying the planting thereof until the season is sufficiently advanced to insure proper growth of the crop, rather than individuals planting early, thereby incubating boll weevils which infest the crops of others.

"It is contemplated that this study will lead to the encouragement of co-operative marketing, it being considered possible that the data will show the advisability of selling cotton through the co-operatives in order to obtain the premium which is paid for the better quality of cotton. The comparison of the price basis in the several communities should show in concrete terms the advantages of the one-variety community practice. The price paid for specific varieties when used in conjunction with data on their productivity, general outturn, and such other information as can be supplied by the experiment stations, would be useful in the establishment of these varieties in the different communities. The information on handling methods, such as excessive sampling, tare, irregularity, etc., would be useful in evolving concrete problems for subsequent studies. The data, together with the observations of those conducting the study, would be useful in arriving at the most advantageous form of community organization for production, gin ownership, and marketing.

"'It would be the purpose of this study to find out the facts as they exist as a basis for improvement in conditions,' declared H. T. Crosby, of the Division of Cotton Marketing, Bureau of Agricultural Economics. 'The plan of operation is to secure actual samples from typical bales, taking in each case a memorandum of the date, variety, buyer's grade, place of sale, and the price paid to the producer for the bale. The hope of the department would be that the results would tend toward single-variety production in the communities.'"

205. COTTON SEED SUPPLY AND CONTROL. As showing what is being done to solve the pure seed problem in South Africa, we publish the following copy of a specimen agreement between the Government of the Union of South Africa and farmers who undertake the growth of pure seed. The agreement has been received from Mr. P. Koch, Principal, Tobacco and Cotton Division, Department of Agriculture.

AGREEMENT entered into BETWEEN the DEPARTMENT OF AGRICULTURE, to be represented by the CHIEF, TOBACCO AND COTTON DIVISION, throughout (hereinafter referred to as the Department) on the one part, and MR. .... of .... (hereinafter referred to as the Grower) on the other part.

1. THE DEPARTMENT undertakes to supply the Grower with .... lbs. Cotton Seed of the Improved Bancroft variety from Special Seed breeding plots of the Government TOBACCO AND COTTON EXPERIMENT STATION, RUSTENBURG, at 3d. per pound.

2. THE GROWER undertakes to receive such seed, and with it to plant a Seed Plot of ground which has been or will be approved of by the DEPARTMENT.

3. THE GROWER undertakes:

(a) To grow no other cotton within a distance of 500 yards from the Seed Plot and to keep a radius of 500 yards from the Seed Plot clear of any volunteer cotton plants.

(b) To carry out any reasonable instructions by the Department regarding cultural methods to be followed in the raising of the crop.

(c) To cultivate and generally care for the Seed Plot to the satisfaction of the Department.

(d) To allow and facilitate inspection of the Seed Plot at any time during the existence of this agreement by any person deputed by the Department.

(e) To keep different pickings separate and mark accordingly, also to keep an exact record of all pickings.

4. In view of special care necessary in the ginning of the crop, the DEPARTMENT reserves the right of stipulating the Ginnery to which the crop shall be sent for ginning.

5. THE GROWER shall advise the DEPARTMENT of deliveries made, and shall deliver at his expense the whole of the crop resulting from the Seed Plot at the Ginnery stipulated, packed in Woolpacks clearly marked with:

(a) The GROWER's initials.
(b) The words "Govt. Seed."
(c) The number of the picking.

6. THE DEPARTMENT reserves the right to supervise the ginning and to decide the time and manner in which the crop shall be ginned and delinted.

7. THE GROWER shall bear the cost of Ginning, Delinting, and Bagging of the seed.

8. THE Lint produced on the Seed Plot shall be the sole property of the GROWER.

9. Immediately ginning is completed, the DEPARTMENT shall hold sole and entire control of all the seed produced on the Seed Plot, and shall, in its own discretion, regulate the selling and despatching of the Seed.

10. (*a*) THE GROWER shall receive payment from the DEPARTMENT for all multiplied seed sold less ½d. (one half-penny) per pound, which shall be deemed accrued to the DEPARTMENT in payment of expenses incurred and services rendered.

(*b*) THE DEPARTMENT shall fix the selling price of the multiplied seed.

11. THE GROWER shall be entitled, free of charge, to one-tenth of the seed produced by himself from Government Seed, and he shall pay all transport expenses in connection therewith.

12. THE DEPARTMENT reserves the right at any time to cancel this Agreement should the GROWER fail to conform to the clauses laid down herein.

13. This Agreement stands for the season 1925-26 only.

206. RELATION BETWEEN WEATHER CONDITIONS AND YIELD OF COTTON IN LOUISIANA. By B. B Smith. (From the *Journ. of Agr. Res.*, Washington, vol. xxx., **11**, 1925.) "*Introduction.*—This study was undertaken to discover to what degree the variations in yield of cotton may be explained on the basis of the available weather data. Obviously the yield of cotton must be greatly influenced by factors which operate prior to our being aware of their effect as measured by the resulting yield. If we may measure these factors as they occur, and then discover a statistical relation between the antecedent conditions and the subsequent yields, we are then in a position to make forecasts of yield at the time the weather conditions occur." In the discussion which follows it is shown that a fairly close relationship was established between the weather conditions prior to September and the subsequent final yield of cotton.

207. SUDAN SOIL ALKALI. By A. F. Joseph. (*Journ. of Agr. Sci.*, 1925, **15**, 407-419. Abstr. *Summ. of Curr. Lit.*, v., **22**, 1925, E. 111.)

208. NITRATE OF SODA AS A COTTON FERTILIZER. (*Austr. Cott. Grower*, **1**, October 1, 1925, p. 10.) A description of results obtained in North America by the use of this manure, which is quickly taken up, and causes early flowering and fruiting.

209. COTTON FERTILIZER TRIALS. By T. D. Hall, Chemist, School of Agric., Potchefstroom. (*Journ. Dept. Agr., S. Africa*, xi., **4**, 1925, p. 357.) Describes a co-operative experiment. Among other things, the result appears to show the bad effects of lime (already noticed elsewhere), and the benefit of superphosphate, but not of potash.

210. THREE-YEAR COMPOST ROTATION EXPERIMENT AT THE NORTH LOUISIANA STATION. By S. Stewart. (*Louis. Sta. Rept.*, 1924. Abstr. from *Exp. Sta. Rec.*, vol. liii, **6**, 1925, p. 514.) The results of long-time experiments with cotton, corn and peas, and oats, receiving an application of a compost of green cotton seed, stable manure, and acid phosphate, are briefly summarized.

211. KEEP THE SOIL FERTILE. (*Farmers' Journ., East Africa*, vol. vii., **43**, 1925, p. 11.) Urging the importance of rotation of crops.

212. GROWTH OF THE COTTON PLANT. By R. D. Martin, W. W. Ballard, and D. M. Simpson. (*Journ. Agr. Res.*, **25**, 1923, 195. Abstr. from *Agr. Journ. of India*, vol. xx., **6**, 1925, p. 491.) Data are presented on the order and rate of appearance and growth of floral buds, the sequence of flowers, and the growth of bolls. The studies have been made under different conditions of growth in three different areas. The records show a very close agreement in the rate of appear-

ance of floral buds and blooms between distinct species and types of cotton grown under different conditions. Considerable variation was observed between varieties in the period of development of the floral bud and in the interval from date of flowering to boll maturation; this indicates the importance of considering the relation of varietal and environmental factors to the growth rate.

213. COTTON PLANT: EFFECT OF TIME OF PLANTING. By W. W. Ballard and D. M. Simpson. (*U.S.D.A. Bull.*, 1320, 1925. Abstr. from *Summ. of Curr Lit.*, v., **20**, 1925, E. 102.) In the season of 1923 comparisons were made of the behaviour of early and late plantings in three widely separated parts of the Cotton Belt. The cotton was planted on four different dates, and measures were taken to prevent the infestation of early plantings by over-wintered weevils. Differences were shown in the rates of growth and fruiting habits of the plants. A more rapid formation of nodes during the seedling stage was found to occur in the later plantings, resulting in a shorter interval between the date of planting and the appearance of the first floral bud. The fruiting capacity of late-planted cotton was found to equal, and in some cases exceed, that of early-planted cotton. The large number of floral buds produced in later plantings was due to the fact that more nodes were produced on the lower fruiting branches. Also, slightly larger numbers of flowers were recorded on the late-planted cotton, although early plantings produced a larger number of flowers during the first part of the flowering period. A separate late planting made at San Antonio showed that thinned plants had a larger individual fruiting capacity than unthinned plants, the difference being counterbalanced, however, by the greater number of plants in the unthinned rows.

214. TRACTOR OR BULLOCK. By A. Classen. (*Cyprus Agr. Journ.*, xx., **4**, 1925, p. 127.) The advantages of tractors, including the quick preparation of the land, which can be done during a short interval of good weather in a bad season, and the saving of upkeep when not at work, are pointed out. The first cost and the working costs are also less in Cyprus.

215. EVERY FARMER HIS OWN GRADER. (*Afr. Cott. Journ.*, i., **17**, 1925, p. 10.) A good elementary account of the qualities—freedom from trash, dirt, and stained cotton—to be aimed at in picking.

216. GOVERNMENT GRADING AND WHAT IT MEANS. By R. Davies. (Abstr. from the *Afr. Cott. Journ.*, vol. i., **23**, 1925, p. 5.) An article to be read by anyone likely to be responsible for grading in any way. It points out, among other things, how the grader is always tempted to grade upwards.

217. COTTON GIN: DESCRIPTION. By G. H. Karmarkar. (Abstr. from *Summ. of Curr. Lit*, v., **19**, 1925, E. 100.) The supply of seed cotton to a gin of the kind described in Specification 187,279 is controlled automatically by a float resting on the surface of the cotton on the reciprocating table. The float is carried by a pivoted lever connected through a link to a shield which covers part of the ratchet wheel on the spindle of the spiked roller which delivers the seed cotton from the hopper. When the float is raised the shield is moved, so that the pawl moves over it instead of in engagement with the ratchet wheel. The pawl is reciprocated by a crank driven by a belt from the ginning roller shaft. A spiked roller controls the feed over the table, and a wiper removes excess from the roller. The roller and wiper are driven by a chain from the shaft of the crank, and are mounted on a pivoted bracket, so that they can be turned back to enable the knives to be adjusted.

218. PIMA COTTON GIN: DESCRIPTION. By J. S. Townsend. (*U.S.D.A. Bull.*, No. 1319, 1925. Abstr. from *Summ. of Curr. Lit.*, v., **20**, 1925, E. 105.) The varied appearance of baled Pima cotton has been due to the mechanical

condition of the cotton caused by the diversity of roller ginning methods in use in Arizona, and not to any lack of uniformity in the cotton itself. The need for uniform methods in the ginning and handling of cotton is emphasized, and an attachment for removing the lint from the gin roller in a way that straightens the fibres and improves the appearance of the cotton is described. The device consists essentially of the replacement of the brush which takes the cotton from the gin rollers by a rapidly revolving auxiliary wooden roller provided with six flexible flaps projecting about ¾ inch from the surface of the roller. By this method the cotton is taken from the gin roller without being folded or rolled, and falls behind the gin in a smooth, fluffy, and uniform condition.

219. Round Bales. (*Int. Cott. Bull.*, iv., 2, No. 14, 1926, p. 197.) The advantages of the round bale, which is being increasingly employed in America, are stated to be as follows: "Round bales are pressed only once at the gin, whilst the high-density square bales are pressed three times. The round bales are sampled only twice, but the square bales are frequently sampled eight times and oftener, according to the number of times the bale changes hands. The round bale is covered with a deep burlap, which protects the cotton entirely until it reaches its destination. The tare of the round bale is 1 per cent., and there are no hoops. Every bale carries the same weight of covering.

"The Clayton press has been further improved in the direction of obtaining a higher density. Whilst until this season the bales obtained a density of 32 lbs. per cubic foot, the improvement has brought about *an average* of 35 lbs., and incidentally less power is necessary. The bales of this new press are 22 inches in diameter and 35 inches long. The Clayton round bales have made a very good reputation in the cotton industry of Europe."

220. Cotton Opener Cage: Description. By J. Bancroft and Howard and Bullough, Ltd. (Abstr. from *Summ. of Curr. Lit.*, v., 21, 1925, F. 22.) The exhaust cage of an opener or cleaner for cotton, etc., is provided with an internal plate shaped to give an air passage of minimum area at the centre and of maximum area at the sides where the cage connects to the ducts leading to the exhaust fan, so as to secure a uniform flow of air over the whole of the width of the cage. The plate can be moved inside the cage to alter its position circumferentially relatively to the cage.

221. Cotton Opening Machinery: Description. By W. Hardman. (Abstr. in *Summ. of Curr. Lit.*, v., 19, 1925, F. 21.)

222. The Scope and Practice of Irrigation. (*Journ. Dept. of Agr., S. Africa*, xi., 4, 1925, p. 329.)

223. The Effect of Irrigation upon Soil Temperatures. By E. McK. Taylor. (*Egypt. Min. Agr., Tech. and Sci. Serv. Bull.* 53, 1924, pp. 1 + 18, pls. 7. Abstr. from *Exp. Sta. Rec.*, 53, 4, 1925, p. 318.) Studies of soil temperatures under various crops and on fallow land receiving irrigation are reported.

It was found that the effect of irrigation is determined mainly by the temperature conditions of the soil immediately prior to irrigation. If the surface soil temperatures are higher than those of the lower layers, increases in temperature of the lower layers take place on irrigation, and *vice versa*. The temperature effects of irrigation are attributed to the displacement of the water already present in the soil by the addition of irrigation water to the surface.

The effect of rain upon soil temperature is shown to be similar to that produced by irrigation water, but not of the same magnitude, owing to the different rates at which the water is placed upon the surface of the soil. It is also shown that the conductivity of the soil is increased by irrigation. The suggestion of Keen and

Russell that the diffusivity of soil increases to a maximum with increasing moisture content, and finally decreases as the moisture content is further increased, was confirmed.

And *cf.* Abstracts 179, 198, 200, 247, 249, 250.

DISEASES, PESTS, AND INJURIES, AND THEIR TREATMENT.

224. Factors affecting Efficiency in Fumigation with Hydrocyanic Acid. By H. Knight. (Hilgardia, California Sta., 1, 1925, No. 3. Abstr. from *Exp. Sta. Rec*, 53, 5, 1925, p. 453.) By means of aspiration tests conducted in a gas-tight fumigatorium, with coccinellid beetles and red scale used as checks, the author found that it requires a mean concentration of about 0·45 per cent. HCN for twenty minutes to kill every insect.

225. The Distribution of an Insecticide made Visible. By A. C. Morgan and R. G. Mewborne. (*Journ. Econ. Ent.*, 18, 1925, No. 2, pp. 299-302. Abstr. from *Exp. Sta. Rec.*, 53, 5, 1925, p. 452.) A method applicable to all dusts of whatever character, and also to sprays, is described.

226. A Method of Computing the Effectiveness of an Insecticide. By W. S. Abbott. (*Journ. Econ. Ent.*, 18, 2, 1925, pp. 265-267.)

227. We have received from the Agricultural Research Institute, Pusa, a copy of *List of Publications on Indian Entomology*, 1924. (Obtainable from the Govt. of India Central Publications Branch, 8, Hastings Street, Calcutta. Price As 8, or 9d.)

228. Importation of Second-Hand Bags: Warning. (Extr. from the *Journ. Dept. of Agr., S. Africa*, vol. xi., 4, 1925, p. 350.) Importers of second-hand bags are cautioned to take adequate precautions against the inclusion of bags that have contained cotton or cotton seed in consignments shipped to them. The Department of Agriculture, South Africa, drastically restricts the importation of cotton and cotton seed, and applies the restrictions to bags that are seen to be contaminated with these articles. It is impracticable to cleanse or disinfect the bags, and impracticable for the inspectors to separate those in which cotton or cotton seed is present from those which may be free of the contamination. Hence, if any cotton or cotton seed is found in a bale of bags, the whole bale is excluded from entry. Bags in which cotton or cotton seed has been transported are almost sure to retain some of the article.

229. The Insect Pests of Cotton. (*Bombay Cotton Ann.*, 1924-25, p. 214.) From this article we quote the control measures advocated for the destruction of the various insects which are the cause of more or less serious damage to cotton in India:

The Pink Boll Worm (*Platyedra gossypiella*): The only methods of control which are of importance are: (1) The destruction of old plants as soon as possible after picking is finished, and the enforcement of as long a period as possible between two successive crops. (2) The treatment of all seed, either by hot air or fumigation, to destroy boll worm larvæ.

Spotted Boll Worms (*Earias fabia*, *E. insulana*, and *E. cupreo-viridis*): Controlled to some degree by natural parasites. No satisfactory control measures have as yet been worked out, though "trap crops" have been advised at various times, and are reported to have been successful in some places, but impracticable elsewhere.

Cotton Stem Borer (*Sphenoptera gossypii*): Control by the systematic destruction of affected plants is simple, and the pest is also partially controlled by several natural enemies.

Stem Weevil (*Pempheres affinis*): Thirteen alternative food plants have been determined in Madras. The destruction of old cotton plants under the Pest Act, so successful in respect to boll worms, has not materially reduced the damage. There seems reason to believe that the difficulty may be met by growing resistant races of cotton.

Cotton Leaf Roller (*Sylepta derogata*): The pest is easily controlled by hand picking in the early stages.

Red Cotton Bug (*Dysdercus cingulatus*): Can be controlled by placing small bags of old cotton seed between the rows of plants; the bugs leave the living bolls for the seed, and are then easily collected and destroyed.

Cotton Aphis (*Aphis gossypii*): The only practical remedy is the growing of hairy-leafed types. Control by spraying would probably be quite simple, but not a practical proposition.

230. THE COTTON INSECT SITUATION, SOUTH AFRICA. By G. C Haines, Entomologist in charge of Cotton Insect Investigations. (*Journ. Dept. Agr., S. Africa*, xi., **4**, 1925, p 361.) The four boll worms are first considered, being the most important enemies of cotton in South Africa, and the difficulties of dealing with them are pointed out. The most promising methods of control appear to be (1) in cultural operations for the destruction of the over-wintering and summer-resting stages in the soil; (2) in dusting or spraying; (3) in trap-cropping with maize; (4) in crop rotation; (5) in the growing of resistant strains; (6) in control with parasites, etc. Jassid, seedling pests, aphis, bugs, boll rot, boll shedding, lint staining, etc., are also dealt with, and a final review says that except for the boll worms the situation is not alarming. Mixed farming is recommended as against dependence on cotton alone.

231. The minutes of a meeting of the Plant Pests Board in Uganda on October 5, 1925 (*Uganda Herald*, October 16), state that the cause of deaths of cotton seedlings in the field has been investigated of late. In general, the fungi and bacteria discovered seem to have been able to make their attack only on seedlings damaged by insect and other pests. Two insects of importance have been discovered—American corn-ear worm (*Heliotis obsoleta* Fabr.), which appears to be doing little damage, and a root grub, possibly the larva of *Syagrus calcaratus* Fabr., which feeds on the roots of the young plants.

232. COMBATING COTTON INSECT PESTS: DIRECT AND INDIRECT METHODS OF CONTROL. By J. D. Young. (Abstr. from the *Austr. Cott. Grower, Farmer and Dairyman*, vol. i., **12**, 1925, p. 4.) An account of the life history of the peach worm, rough boll worm, maize grub, and pink boll worm, which constitute the chief pests of cotton in Queensland. Direct methods of control—*i.e.*, by spraying with arsenical compounds—are not considered practicable or profitable, owing to the high cost of labour and of poison preparations in the State. The indirect methods of control mentioned include the protection of bird life, the clean-up of the cotton fields after the crop is picked, good winter cultivation, and the employment of the maize trap crop. It is stated that the trap-crop method would be effective in the case of all the pests with the exception of the pink boll worm, as this insect lives only on cotton. The maize is planted in rows between the rows of cotton, and when in "silk" is more attractive to the moths, so that the maize must be timed to reach this stage during the flowering and early bolling of the cotton.

233. In the REPORT ON THE ECONOMIC AND FINANCIAL CONDITIONS IN THE BRITISH WEST INDIES, by J. L. Wilson Goode, a statement occurs on p. 19 to the effect that boll *weevil* is ravaging Barbados. The Corporation at once made inquiry through the Department of Overseas Trade, and found, as expected, that it is the boll *worm* that is causing the damage, the boll *weevil* being unknown in the West Indies, or indeed outside of the American continent.

234. Boll Weevil Control by Airplane. By G. B. Post. (*Ga. Agr. Col. Bull.* 301, 1924, pp. 22, figs. 11. Abstr. from *Exp. Sta. Rec.*, 53, **4**, 1925, p. 363.) An introductory statement by A. M. Soule is first presented, followed by a letter from B. R. Coad of the U.S.D.A. Bureau of Entomology. The author then discusses the principles, advantages, and organization of airplane dusting at some length.

235. Cotton Boll Worm attacking Citrus Fruit. (*Rhod. Agr. Journ.*, xxii., No. 8, 1925, p. 854.) The American boll worm, *Chloridea obsoleta*, has been a serious pest of oranges, etc., during the season. As arsenical sprays could not be used, difficulties in treatment have arisen.

236. Cotton Boll Worm: Life History. By P. Vayssiere and J. Mimeur. (*Rev. Appld. Entomol.*, 1925, **13**, Series A, 170. Abstr. in *Summ. of Curr. Lit.*, v., **22**, 1925, E. 112.) The spiny cotton boll worm (*Earias insulana*) occurs practically wherever cotton is grown, except in North and South America. It is one of the major pests of cotton in Africa. It appears to have decreased in numbers in Egypt since the invasion of Egypt by the pink boll worm, but in French West Africa it is still one of the most serious pests. The various stages of its life history are described. The eggs are laid on all parts of the plant, but chiefly round the flower buds and capsules, and at the points of the leaves and bracts. The emerging larvæ penetrate the young branches or buds. The cocoon is found in various positions on the plant. The durations of the egg, larval, and pupal stages vary according to the season from 3-12, 15-28, and 10-52 days respectively. In April in the Sudan a cycle is completed in 32 days. The generations are continuous throughout the year in Egypt. In Senegal and the Sudan *E. insulana* occurs from February to July on bi-annual cotton plants and some species of Hibiscus and Malvaceæ, particularly those growing in humid places. Natural enemies are recorded from Egypt and India. *E. biplaga* is very similar in life history to *E. insulana*. It occurs in all African cotton-growing districts, and apparently only on cotton.

237. Scavenger Boll Worm of Cotton. (Abstr. from *Journ. Dept. of Agr., S. Africa*, vol. xi., **5**, 1925, p. 380.) This insect is a small pinkish caterpillar somewhat resembling the pink boll worm, which has lately appeared on cotton in South Africa. It is the larva of a small moth of the genus *Pyroderces*, and invariably puts in an appearance late in the season. As it is only found in the debris and tracks of other boll worms, and does not seem to be responsible for any primary damage, *it is regarded as a scavenger where cotton bolls are concerned.* The specific determination of this *Pyroderces* is not yet fully decided, although it is regarded provisionally as *P. simplex.*

238. *Pink Boll Worm, Montserrat.* By C. A. Gomes. (Abstr. from *Trop. Agriculture*, iii., **2**, 1926, p. 23.) A report on the damage caused by pink boll worm in the 1925 cotton season, and of the measures of control suggested. It is estimated that the loss of cotton in Montserrat due to this insect is equal to about 25 per cent. of the total crop, amounting, at present prices, to about £10,000.

239. A Trinidad Cotton Pest, Sacadodes pyralis. By C. L. Withycombe. (Abstr. from *Trop. Agriculture*, vol. ii., **12**, 1925, p. 286.) An interesting description of a moth, closely related to the Sudan boll worm, which has lately become troublesome as a pest of cotton in Trinidad. The moth was first described as *Sacadodes pyralis*, a new genus and species, by H. G. Dyar in 1912. (See *Proc. Entom. Soc., Washington*, xiv., 1912, pp. 167-168.)

240. Cotton Stainer. By A. W. J. Pomeroy. (*Rev. Appld. Entomol.*, 1925, **13**, Series A, 16. Abstr. from *Summ. of Curr. Lit.*, v., **22**, 1925, E. 119.) Experiments in which adults of *Dysdercus superstitiosus* were placed on young bolls,

the buds having been screened before they showed signs of opening, show that the stainer can cause shedding of the bolls by the mechanical action of puncturing them, or that boll disease may be introduced while the cotton is in the flowering stage. Unless the carpel wall is pierced, however, no injury to the boll results either from the insect, or in all probability from the disease. Internal prolifera-tion does not take place unless the carpel wall is pierced, and is not an essential factor in the shedding of young bolls, but rather indicates injury from an external source. Puncturing by stainers of the buds and flowers before the flower petals have fallen off may cause the shedding of the boll and the introduction of the disease. Bolls kept free from insect attack do not develop the symptoms of internal boll disease or the condition typical of stainer or boll worm injury. Combined injury by Dysdercus and the larvæ of Lepidoptera produces in most cases typical injury by both and also boll disease, but in an instance where the stainer died without puncturing the boll and the larva died without piercing the carpel wall the boll developed normally. Aphids occur occasionally in Southern Nigeria, but they do not pierce the carpel wall, whilst boll worms invariably bore through the boll and destroy the interior.

241. COTTON PESTS IN THE BELGIAN CONGO. By J. Ghosquiere. (*Rev. Appld. Entomol.*, 1925, **13**, Series A, 453. Abstr. from *Summ. of Curr. Lit.*, v., **22**, 1925, E. 115.) Among the insects mentioned are the following: *Heliothis obsoleta*, *Earias insulana*, and various cotton stainers, of which the *Dysdercus nigrofasciatus* and *D. fasciatus* are the most widely distributed in the district under review. A list of the various trees serving as food plants for *Dysdercus* is given, and their destruction is recommended.

242. CUTWORMS—THE FARMER'S ENEMY. (*Afr. Cott. Journ.*, i., **17**, 1925, p. 15.) Advocates keeping the land as clean as possible while the plants are young, ploughing in autumn to keep down the winter weeds that supply food to the pest, and the actual destruction of the insect by a bait composed of small pieces of prickly pear steeped in a solution 6½ ozs. of commercial sodium fluoride in 2 gallons of pure soft water. The bait to be used daily, as it does not keep, and to be spread after the weeds are destroyed.

243. FUNGUS PESTS: THE WORK OF THE IMPERIAL BUREAU OF MYCOLOGY. By Sir Arthur E. Shipley. (*Trop. Agriculture*, vol. ii., **12**, 1925, p. 271.)

244. METEOROLOGICAL CONDITIONS AND PLANT DISEASES. By Dr. E. J. Butler. (Abstr. from *Trop. Agriculturist*, vol. lxv., **4**, 1925, p. 223.) *Sore-shin Disease.*—The earliest and still one of the most complete studies of the influence of temperature on a soil-dwelling parasite was made by Balls in Egypt in 1905-06 on the sore-shin disease (*Rhizoctonia solani*) of cotton. The damage done by this disease is usually restricted to the first stages of development of the seedling. Once cork formation begins, damage ceases. Cotton is sown in Egypt at different times between the end of February and May. The earlier sowings may take about twelve days to appear above ground, while in the middle of April the seedlings may be up in five days. Growth of the cotton root increases with a rise of temperature in an accelerated curve, which ceases rather suddenly at about 37° C. The parasite—a fungus universally present in Egyptian soils—has a similar growth curve, ceasing very abruptly at about the same point (37° C.). It was determined with considerable probability, especially in the case of the fungus, that inhibition of growth at the higher temperature was due to auto-intoxication of much the same type as the well-known staling phenomenon in bacterial cultures. The toxin is produced even at the lower temperatures, but is too slowly formed to accumulate sufficiently to inhibit growth, unless the medium is scanty or the cultures are kept for longish periods, until the temperature approaches 37°C. Then it is formed more rapidly than the fungus can stand, and growth ceases. When

the fungus encounters the young tissues of the cotton seedling at a temperature of, say, 20° C., these are penetrated, and the hyphæ pass from cell to cell, destroying the tissues before the toxin has time to accumulate sufficiently to check their growth. But at temperatures approaching 33° C. auto-intoxication is more rapid and growth is delayed. At the same time, at this temperature (33° C.) the cotton plant has its vital activities near their optimum. Hence defensive cork formation is vigorous, and the parasite is checked after producing only a small scar. At 37° C. not even a scar is produced, growth of the fungus being entirely inhibited. Thus the late-sown seedlings normally escape attack, but a cold spell of even a couple of days in May will cause the death of many of them. The seasonal prevalence of this disease in Egypt is, therefore, practically a purely temperature reaction, affecting chiefly the parasite.

245. The Life History of the Texas Root Rot Fungus (Ozonium omnivorum, Shear). By C. L. Shear. (*Journ. Agr. Res., U.S.*, 1925, No. 5. Abstr. from *Exp. Sta. Rec.*, vol. liii., **6**, 1925, p. 544.) The author describes as *Hydnum omnivorum* n. sp. what he believes to be the perfect form of the Texas cotton root rot fungus generally referred to as *O. omnivorum.* The fungus described was found on the Osage orange, not far from dead and dying cotton plants. The perfect stage of the fungus is believed to occur as a saprophyte also, as similar specimens were found on over-wintered cotton stalks killed by the root rot. All efforts to grow the fungus from the Hydnum failed.

246. Cotton Disease in Egypt: How to Fight It. By A. M. Psalti. (*Egyptian Gazette*, November 11, 1925.) The yield of cotton in Egypt has decreased very greatly in recent times, and this the writer puts down to (1) pink boll worm, (2) the rise of the water table, and (3) deterioration of seed through mixture. He then goes on to deal with sore shin, a disease which is much on the increase (*cf.* Abstract **122** in last number, p. 71), and which does most damage when the temperature is rather low. During the past year it has been unusually harmful. The author's experiments showed uspulin to be useful in dealing with this disease. Pink boll worm is supposed to cause an annual loss of £7,000,000, and methods of dealing with it are described; the compulsory burning of all the old cotton after a certain date is suggested as a most useful measure to be adopted.

And *cf.* Abstracts 182, 187, 196.

BREEDING, GENERAL BOTANY, ETC.

247. Cotton Seed Control. By T. K. Wolfe, L. W. Osborn, and J. R. Fain. (*Journ. Amer. Soc. Agronomy*, 1925, **17**, 500-508. Abstr., *Summ. Curr. Lit.*, vol. v., **19**, 1925, p. E. 101.) A scheme for the certification and registration of field-crop seed by seed associations, intended to lead to the production and distribution of improved, high-yielding, and adapted seed, is outlined. The requirements for the certification of cotton seed are as follows: The sources of foundation stocks must be approved by the seed association. Care must be taken at planting to make sure of the purity of the seed. The cotton may be ginned by any standard gin, but where a single variety only cannot be ginned, careful cleaning methods must be employed or special days reserved for ginning different varieties. The seed should be put through a good recleaner and grader. Field inspection will occur at any time after the opening of the first bolls until three-quarters of the crop has been picked. Seed is also sent to the association secretary for examination at the State seed laboratory. In labelling seed, the State seed law is to be upheld. Careful attention must be given to storage of the ginned seed.

248. NOTES ON THE TAXONOMY OF AMERICAN AND MEXICAN UPLAND COTTONS By F. L. Lewton. (*Journ. Wash. Acad. Sci.*, 15, 1925, No. 4, pp. 65-71. Abstr. from *Exp. Sta. Rec.*, 53, 4, September, 1925, p. 337.) Review of early publications suggested that neither *Gossypium mexicanum* nor *G. siamense* is a suitable name for American Upland cotton. For more than a century "Siam Cotton" was a general name given to several species or varieties of West Indian cottons having tawny or brownish lint, and to occasional white forms of those. No valid evidence seems to have been brought forward to indicate an Asiatic origin for American Upland cotton.

249. DISCUSSION ON "THE VALUE OF SELECTION WORK IN THE IMPROVEMENT OF CROP PLANTS"; DEFECTS IN THE THEORY AND PRACTICE OF SELECTION. By W. L. Balls, F.R.S. (*Report Imper. Bot. Conf.*, London, 1924.) Dr. Balls pointed out that in the theory of selection we seem to be in need of much clearer concept and stiffer definition of phenomena. He considers Johannsen's work on pure lines as the most important for the working agricultural botanist, and points out the advantages of pure line formation, especially that no work need be wasted, for the selected seed can be preserved for long periods, and even one seed may be multiplied (in cotton) to a great quantity in three years. The risks of accidental admixture, even with careful precautions, are pointed out.

250. UNE DECOUVERTE SENSATIONELLE? LA SELECTION BIOLOGIQUE DES GRAINES DE COTON. (*Bull. Assoc. Cotonn. Colon.*, 71, 1925, p. 49.) An abstract of an article in *L'Egypte Nouvelle*, by G. Vaucher, describing the serum method of M. Nasra for selection of the best seed, a method which can apparently be practised by the cultivator himself.

251. COTTON IN BRITISH GUIANA: INDIGENOUS VARIETIES. By the late Mr. Hillhouse. (*Trop. Agriculture*, vol. ii., 12, 1925, p. 273.) Mr. Hillhouse went into the interior of British Guiana in 1828-29; this paper was written by him at the time, and the description of the different varieties of the cotton plant collected by him on his travels is of much historic interest.

And *cf.* Abstracts 178, 183, 187.

CHEMISTRY AND PHYSICS IN THEIR APPLICATION TO COTTON PROBLEMS.

252. SCIENCE AND THE TEXTILE INDUSTRIES. By Sir James Hinchliffe. (*Text. Recorder*, vol. xliii., 514, 1926, p. 92.)

253. THE MECHANISM AND GROWTH OF THE COTTON FIBRE. By Y. S. Thackeray. (*Anglo-Gujarati Quarterly Journ.*, xviii., October, 1925, p. 68.) An elementary account of the formation and growth of the cotton hair, pointing out more particularly the serious differences that exist among the hairs in one pod, according to their place of origin upon the seed and the date at which growth commences.

254. FIBRES: MOISTURE RELATIONS, STRENGTH WHEN WET. By J. Obermiller. (*Z. angew. Chem.*, 1925, 38, 838-839. Abstr. in *Summ. of Curr. Lit.*, vol. v., 18, 1925, C. 115.) In connection with the importance of controlling relative humidity in textile mills, series of experiments have been made on the relation between the moisture content of fibres and the humidity of the surrounding air. They were carried on without interruption for more than two years at several different humidities and at a constant temperature of 20°C., and moisture curves for the fibres have been drawn. These curves show that in absolutely dry air fibres lose all trace of moisture even at ordinary temperatures; in moist air, wool, silk, cuprammonium and viscose silk, and cotton appear to take up respectively more than 32, 35, 40, and 26 per cent. of moisture calculated on the dry weight of the fibre.

Some 10,000 measurements of the strength of single fibres were made by a special method, and the following figures for "relative wet strength" are given: cotton, 110 to 120 per cent.; cellulose acetate silk, 65 to 70 per cent.; cuprammonium silk, 50 to 60 per cent.; viscose silk, 45 to 55 per cent.; nitro-silk, 30 to 40 per cent.

255. Some Common Faults in Cotton Goods. By F. Summers, B.A., M.Sc. (*Journ. Text. Inst.*, xvi., November, 1925, p. T. 323.) Faults due to the presence of neps, yarn discolorations, barring produced by irregularity or due to mechanical faults, and faults produced during mercerization, are here considered.

256. Cotton Waste: Sources. By A. Richter. (*Melliand's Textilberichte*, 1925, **6**, 642-643. Abstr. from *Summ. of Curr. Lit.*, v., **21**, 1925, F. 22.) Some general notes on the different kinds of cotton waste arising from the different processes of cotton manufacture, and a short note on the mechanical treatment of cotton waste to improve its quality.

257. Cotton Fabric: Mercerization. By P. P. Budnikoff. (Abstr. in *Summ. of Curr. Lit.*, v., **21**, 1925, K. 129.)

258. The Lustre of Raw Cottons and of Folded Yarns Spun from Them. By A. Adderley, B.Sc. (*Journ. Text. Inst.*, xvi., November, 1925, p. T. 352.) The length of the staple has an important influence on the lustre of the yarn, longer staple giving better results.

259. Wool-Like and Other Effects on Cotton. (Abstr. from *Text. Recorder*, vol. xliii., **514**, 1925, p. 77.) The effects that may be produced by treating cotton with concentrated nitric acid are fairly well known, but it is now claimed (German patent 412,333) that such effects may be considerably improved upon by treating the cotton, after the application of the strong acid, with pyridine or its homologues. A greatly improved wool-like appearance is stated to be thus imparted to the cotton. After-treatment with ammonia imparts an effect more like that exhibited by linen.

260. Cotton Cloth: Effect of Heat. By F. Driessen. (Abstr. in *Summ. of Curr. Lit.*, v., **21**, 1925, K. 129.)

261. Cotton Cellulose: Its Chemistry and Technology. By A. J. Hall. (London: Ernest Benn, Ltd., 1924. Abstr. from *Exp. Sta. Rec.*, vol. liii., **5**, 1925, p. 412.) The scope of this volume on the chemistry and technology of cotton cellulose is indicated by the chapter headings, which are as follows: Cotton and Cellulose, Raw Cotton and its Purification, Cotton and Alkalies, Cotton and Acids, Cotton and Various Reagents, Cellulose and Oxidizing Agents, Cellulose and Dyes, the Constitution of Cellulose, Cellulose and its Technically Important Modifications, and Selected Methods of Analysis. The usefulness of the volume is increased by tabulations of data and many illustrations.

262. The Nature of Solutions of Cellulose in Cuprammonium Hydroxide. By S. M. Neale, M.Sc. (*Shirley Inst. Mem.*, iv., 1925, No. xi.)

263. The Waxes of Cottons of Different Origin and their Characteristics: Identification of the Fatty Ingredients in Sized Goods. By L. V. Lecomber, B.Sc., and M. E. Probert, B.Sc. (*Journ. Text. Inst.*, xvi., November, 1925, pp. T. 338, T. 345.)

264. Powdered Cotton: Preparation. By F. Bayer and Co., K. Mersenberg and W. Lenhard. (*Chem. Zentr.*, 1925, **1**. Abstr. from *Summ. of Curr. Lit.*, v., **20**, 1925, B. 110.) Cotton is prepared by milling in powder form, in which it is very suitable for carrying out chemical reactions such as etherification and esterification; the cotton is not changed chemically.

MISCELLANEOUS.

265. On Reducing the Cost of Production of Cotton. By Ed. C. Segundo. (Abstr. from *Int. Cott. Bull.*, vol. iv., 2, No. 14, 1926, p. 252.) Deals with one of the possible methods—the better employment of the short fibres—which are useful for artificial silk and other purposes. The defibrating should be done at the ginnery.

266. Forecasting the Acreage of Cotton. By B. B. Smith. (*Journ. Amer. Statis. Assoc.*, 20, 1925. Abstr. from *Exp. Sta. Rec.*, vol. liii., 6, 1925, p. 592.) The factors which influence the farmer's opinion as to crop probability are outlined, and methods of determining the quantitative relation existing between these factors and the acreage planted are presented. From an analysis of prices there was found to be practically no difference between the New Orleans and New York price series. With the exception of the November series, the fluctuations in price series prior to 1907 were considerably greater in proportion to the acreage series than subsequently, when the ratio seemed to be fairly constant. If the acreage figure was below the price for one month, a similar condition prevailed for the other months in the related year. January and February were found to have probably closer relation to acreage than other months except November. The influence of the passage of time was provided for in mathematical analyses, but the net correlation was so small that in later analyses it was omitted. Examination of the coefficients of determination indicated that the price series were more important than the production and yield value, or that prices had more to do with determining the producer's mind than the other factors.

Average monthly middling spot quotations on the New York and New Orleans markets for the harvest years 1901 to 1923 inclusive, and data with respect to production, yield, and acreage in the same years, were used in this study.

267. Price of Cotton in Relation to Other Farm Products. (*Int. Cott. Bull.*, vol. iv., 2, No. 14, 1926, p. 199.) Cotton growers in the important cotton-producing countries are now enjoying an advantage over producers of other commodities as far as can be determined by statistics available. The American cotton grower has enjoyed a relative advantage over most growers of other agricultural commodities since 1921. The following table shows the combined farm price in the United States of cotton and cotton seed, weighted according to value and expressed as a percentage of the average for the period August, 1909, to July, 1914, compared with a similar index of farm prices of thirty commodities:

Year.	*Cotton and Cotton Seed.*	*Thirty Farm Products.*
1921	101	116
1922	156	124
1923	216	135
1923	211	134
1925 (July)	186	148

A similar situation exists in Egypt, the average price of good fair Sakel at Alexandria for 1924 being 221 per cent. of the average for January 18, 1913, to July 31, 1914, as compared with a wholesale index of 141 for other commodities, mostly agricultural. In India for July, 1925, the wholesale price of raw cotton at Calcutta was 215 per cent. of the price in July, 1914, as compared with 135 per cent. for cereals and 180 per cent. for miscellaneous food articles.

268. Thirteenth Indian Science Congress. (Presidential Address by Albert Howard, C.I.E., Director of the Institute of Plant Industry, Indore.) This is a valuable paper on present-day tendencies in the application of science to agri-

culture, which should be read by all concerned with the training of men for service in Agricultural Departments. The author points out the gradual broadening of the attack of science upon agriculture from the original introduction of chemistry by Liebig. More and more branches of science are coming into play, and Howard considers the question of possible "team-work" attack on many problems, rejecting it as usually impracticable (on various grounds), and suggesting that it may be better to "so widen and deepen the training and post-graduate experience that the individual can successfully attack problems now attempted by the team."

Special sections of the address are devoted to Irrigation and to Plant Diseases. In the first the many disasters and injuries due to the extension of the great modern systems of irrigation are pointed out, and an appeal is made for proper scientific investigation of the whole subject. In the second, the steady growth of the opinion that protection against disease is rather to be sought on the agricultural and genetic side than on that of pure mycology or entomology, is described. "Disease follows the breakdown of the normal physiological processes in the plant when the protoplasm of the cells loses its power of resistance to the inroads of parasites. Healthy plants, on the other hand, possess a high degree of immunity to insects and fungi. It is obviously more practical to prevent disease altogether by growing the right kind in the right way than to step in at the last moment and attempt to save a moribund crop."

269. West Indies. *The Imperial College of Tropical Agriculture, Trinidad.* With the Prospectus for the year 1925-26, recently issued, is published an interesting report on the academic year 1924-25 by the Principal, Dr. H. Martin Leake; this constitutes a new departure, and one which is to be welcomed.

We learn from the report that the Entrance Examination, which had hitherto been held for the admission to the Diploma Course of those students who did not possess any accepted qualification, having proved unworkable in practice, was discontinued, and replaced by a system of recommendation. Admissions to the Diploma Course for the Session 1924-25 were six, making a total in the College of eighteen. In addition, twelve students, of whom six were sent by the Empire Cotton Growing Corporation and four by the Colonial Office, joined the College to take a post-graduate course, while four joined to take a special one-year course. The final Diploma examination was held in June, when seven students appeared, and five qualified for the Diploma. During the year the conditions for the Associateship were laid down, the first Associateship being awarded to Mr. J. C. Hopkins. Post-graduate students who have already left are now eligible for this Associateship. At the end of the academic year students who had passed through the College were holding appointments in the Gold Coast, Sudan, South Africa, Ceylon, West Indies, and to these countries may now be added Uganda, Southern Rhodesia, Nyasaland, Natal, and British Guiana.

Dr. Leake stresses the need for the provision of a hostel, as owing to the increase in the number of students accommodation in the neighbourhood is limited and by no means easy to obtain. Plans are in preparation, and financial assistance alone is required to proceed with the work. Financial help is also required for the development of an estate which Dr. Leake regards as necessary if students are to secure a practical knowledge of the crops under economic conditions. Again, it is essential that each professor be provided with an assistant, so that when he is on leave or on a mission to another island, the continuity of the work may not suffer through his absence.

In the section devoted to "Research and Investigation," it is stated that the following research work on cotton is being carried out: (1) Attempts to evolve an Egyptian cotton with the staple of Jannovitch and suited for growth in the West Indies; (2) efforts to improve the staple of Marie Galante perennial cotton;

(3) investigation on the effect of different water supplies on the characteristics of the lint; (4) genetic investigations on various characters of the cotton plant; (5) further study of the Cotton Stainer, with special relation to variability in connection with migration.

A list is given of the various papers published during the year, and of the journals in which they have appeared.

A College Register is included at the end of the Report, and forms a complete record of the staff and of the students who have passed through the College since ts inauguration in 1922.

PERSONAL NOTES

We offer our congratulations to Sir John Farmer on receiving the honour of knighthood. Sir John Farmer is Professor of Botany and Director of the Biological Laboratories of the Imperial College of Science and Technology, London. He is also a member of the Advisory Council to the Department of Scientific and Industrial Research, a Governor of the Imperial College of Tropical Agriculture, Trinidad, and a member of the Research and Training Committee of the Corporation.

APPOINTMENTS.

Cotton Research Station, Trinidad.—The following appointments have been made to the staff of the Cotton Research Station: Dr. S. C. Harland, as Head of the Genetics Department, and Dr. T. G. Mason as Head of the Physiological Department. Mr. J. B. Hutchinson has been appointed to assist Dr. Harland, and Dr. E. J. Maskell will assist Dr. Mason.

OFFICERS ON LEAVE.

When an officer of a colonial Department of Agriculture (or of the allied departments of Irrigation, Transport, etc.) comes "home" on leave, he usually brings with him much information that may be of considerable value to similar officers in other colonies, or to the officers of the Empire Cotton Growing Corporation, who have to collect, collate, and use all possible information relating to cotton. The Corporation would consequently much appreciate the courtesy if Directors of Agriculture and others would be so kind as to inform them, in advance if possible, of the names, probable addresses, and approximate dates of arrival in England of officers coming on leave. This would give the Corporation the opportunity of getting into touch with these officers themselves, and of giving the latter the opportunity of meeting with one another. A further courtesy would be conferred if the officers themselves, upon arrival, would call at, or inform, the offices of the Empire Cotton Growing Corporation, which are at the corner of Millbank and Wood Street (entrance by the first door in Wood Street) immediately opposite to the offices of the Crown Agents for the Colonies.

At the date of writing the following officers from cotton-growing countries are on leave in England, or will arrive shortly:

Gold Coast	Mr. T. Hunter.
India	Mr. G. Clarke.
"	Mr. G. R. Hilson.
"	Mr. W. Youngman.
Kenya	Mr. W. L. Watt.
Tanganyika	Mr. T. H. Marshall.
Uganda	Mr. S Simpson.

Mr. G. Evans, C.I.E., Director of Cotton Culture, Queensland, will arrive on leave in this country early in April.

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Cotton Specialist - Mr. E. F. SALTER

NYASALAND

Cotton Specialist - Mr. H. C. DUCKER
Assistant - - Mr. T. MCEWEN
Entomologist - - Mr. C. B. R. KING
Farm Manager - - Mr. W. L. MILLER

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Plant Breeder - - Mr. M. A. BAILEY
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Mr. J. C. F. HOPKINS

AUSTRALIA

Cotton Entomologist - Mr. E. BALLARD

QUEENSLAND

Director of Cotton Culture - - Mr. G. EVANS, C.I.E.

FIJI

Cotton Specialist - Mr. R. R. ANSON

WEST INDIES

COTTON RESEARCH STATION, TRINIDAD

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Assistant Geneticist - Mr. J. B. HUTCHINSON
Physiologist - - Dr. T. G. MASON
Assistant Physiologist Dr. E. J. MASKELL

THE EMPIRE COTTON GROWING REVIEW

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COTTON GROWING IN SOUTH AFRICA

BY

G. F. KEATINGE, C.I.E.

THREE years ago I had the good fortune to visit the principal cotton districts of South Africa, with a view to obtain an idea of the existing position and future prospects of cotton-growing in that region. The information that I then gathered was recorded in a report to the Empire Cotton Growing Corporation. My general conclusion was that in certain parts of South Africa physical conditions were very favourable for cotton-growing, and that there was likely to be a considerable development of this industry in the near future. It was therefore a matter of much interest to me to revisit South Africa in the latter half of 1925, and to revise the conclusions that I had previously formed in the light of two and a half years' further experience. The experience to which I refer is the experience of the many cotton-growers with whom I had the advantage of discussing the matter, for I have never grown cotton myself in South Africa nor even watched it grow for a whole season. All that I can do is to record what I saw and heard, and interpret the facts as best I can with the help of my experience elsewhere.

It was not until 1919 that the annual production of cotton in South Africa reached the figure of 1,000 bales. By 1922 the figure was between 2,000 and 3,000 bales, and in 1925 was probably about 10,000 bales. Increase has therefore been fairly rapid of late years but not so rapid as it promised to be in 1923. After the harvest of that year, which was generally satisfactory, there was great enthusiasm on the part of cotton-growers, and much bush land has since been cleared and broken for cotton cultivation. At present, however, the position is peculiar. Some farmers are still enthusiastic in the matter, and are feverishly breaking land for sowing to cotton at the

earliest possible moment; while others are hanging back or actually giving up cotton-growing as a result of unfortunate experience. Ask the latter to account for their objections to cotton and they will give one or more of the following reasons: The crop of 1924 suffered from drought; the crop of 1925 suffered from excessive rain; both crops suffered from insect pests. These objections are valid so far as they go, but they hardly go to the root of the matter. It may be admitted that the experience of 1925 was very disappointing, when an excellent crop, almost ready for picking, was ruined in March by a period of continuous rain for three weeks, followed by another period of damp, cloudy weather. It may also be admitted that insects have done much damage to cotton, and do constitute a serious danger. It remains, however, to consider how far such difficulties may be surmounted, and how far profitable cotton may be grown, here as elsewhere, in spite of such drawbacks.

Before considering the characteristic difficulties of cotton-growing, it may be as well to point out that some of the trouble has been due to more general causes. Much of the land sown to cotton during the last few years has been land which had only just been stumped and broken. To remove a large tree-stump often involves digging down several feet, and in this way much raw soil is brought to the surface. A first ploughing is often given to a depth of 10 inches, which also has the effect of bringing up raw soil. Further, land just broken is often full of large lumps of grass roots, which greatly obstruct the tillage. In some of the lighter and more open soils fair crops are sometimes obtained even under those conditions; but in the heavier soils the first crop starts with a very heavy handicap.

There is another direction in which farmers have gone half-way to meet trouble. They have grown cotton after cotton continuously for a series of years, in defiance of ordinary agricultural theory. So far as the fertility of virgin soil is concerned, it is probable that little damage has as yet resulted. Even where cotton has been grown continuously on the same land for five or six years, it is stated that large and healthy plants are still produced with no diminution in vigour. What, however, is probable is that the undoubtedly serious attacks of insect pests are connected with the practice of growing cotton continuously from year to year on the same land. This is a matter which will be discussed later.

It is, perhaps, unnecessary to refer to disasters due to unsuitable soils, to scouring on sloping land, or flooding from an adjacent river. Enthusiasm for cotton has led some farmers to fancy that cotton

would grow anywhere, and that success was so well assured that it was safe for a man to risk his whole capital on the venture of a single crop. Everyone who visits South Africa will hear of such cases and will even hear them quoted as an argument against cotton-growing, but they are matters obviously connected with general farming and with common sense, and not peculiar to cotton.

The tract which I visited in the latter part of 1925, and with which I shall now deal, is the strip on either side of the Lebombo range, in Swaziland, Transvaal, and Natal on the west, and on the east in Portuguese East Africa, between the Lobombo mountains and Lourenço Marques. The climatic conditions of this tract are suitable for cotton, and there are large stretches of excellent soil. On either side of the Lebombo mountains there is a strip of approximately flat or gently sloping country containing good alluvial soils of late volcanic origin. These soils are anything but uniform, and in some places vary greatly in small areas. Some of them are obviously on the light side, and are likely to work lighter when broken and cultivated for a number of years, though they may include soils with a good texture for absorbing rainfall and retaining moisture. Others are as obviously on the heavy side and, though rich, present difficulties in tillage. In this class also there are some which at first sight appear to be too heavy, but which, on closer inspection, are found to contain a large proportion of grit and pebbles which keep them open. Between the extremes of light and heavy there are large areas of intermediate soils, medium loams with a nice open texture, and every appearance of fertility. These vary considerably. Many are attractive, and perhaps the most attractive are those which contain a large admixture of volcanic ash. A farmer would be hard to please if he could not find a soil to suit his taste amongst all this variety. Let us suppose that a good farm has been selected in this locality, handy to a river with perennial water, but safe from flooding, containing varied soils with a good proportion of free-working, fertile loam, reasonably near to a railway station, and with no outstanding difficulties of communication. What are the principal difficulties which the cotton-grower on such a farm may have to face? They have already been indicated: drought, excessive rain, and insect pests. Let us consider these in turn.

Details of rainfall extending over a number of years are difficult to obtain for this tract. Averages are hopelessly misleading; annual totals are of very little use, and even monthly totals give little guidance. I was fortunate in obtaining in Portuguese East Africa the daily record of rainfall for twelve years, from which it could be seen that

the cotton-grower had to be prepared for great variation in the rainfall of different years. The effective rainfall (say from October to March) may be anything from 12 to 50 inches. A study of these records appeared to indicate that, given a fairly retentive soil and good tillage, two of the twelve years would have given good cotton crops, five would have given fair cotton crops, three moderate, and two poor. There were three years in which drought would have done damage, and four years in which excessive rain would have done damage. Drought occurred most often in the months of December and January, and excessive rain in January and February. On the west of the Lebombo mountains I could not obtain detailed records extending over many years for the strip known as the Lebombo flats, but a comparison of such records as I could obtain with those taken on the east side of the range appeared to indicate that the minimum rainfall was similar, but the maximum rainfall much less. The very heavy downpours that occur on the eastern side were markedly less on the western side of the mountains. If one were to try to generalize, one might hazard the opinion that the thing most to be feared on the western side was drought and on the eastern side excessive rainfall.

DROUGHT.—In dealing with drought there are two matters of great importance—the selection of the right kind of soil, and effective tillage. Speaking generally, it is the light soils that the rainfall will penetrate most easily, but it is the heavier soils that will retain their moisture best. With a medium soil the farmer takes the least risk, but if he has a variety of soils on his farm, he would be well advised to experiment on several of them and to note their behaviour and the movements of soil moisture in time of rain and of drought. It is not necessary for me to expatiate on the necessity for good tillage and mulching in this connection, but one question is worth raising, and that is the possibility of securing bumper crops by means of an alternate bare fallow, as is done by the wheat farmers in the semi-arid tracts of U.S.A. Apart from such advantages as may result from the maintenance of soil fertility and the avoidance of insect pests, the bare fallow would present an excellent seed-bed for early sowing, and with the proper tillage there should be no seasons when the crop would suffer from deficient moisture. In countries where the population presses on the soil, and land is costly, such a practice presents economic difficulties; but in the Lebombo flats, where excellent land can be purchased for £1 an acre, and cleared and broken for another £2 an acre, the experiment is certainly worth an extended trial.

Excessive Rain.—This presents a very difficult problem to the farmer. He can choose land not subject to flooding or to violent scouring, but even when he has done this, he may have to watch his crops severely damaged by excessive rain, which on rare occasions may amount to 10 inches in a day or 30 inches in a month. If the excessive rain occurs as late as the month of March, as it did in 1925, the damage is particularly serious, since the cotton is then ripening, and if it sheds its bolls then it has a long way to make up. Even so, on suitable land cotton will usually recover, and good pickings were being made as late as August during the past season. If excessive rain occurs, however, it usually comes in January or February. What can the farmer do to save his crop? I do not suggest that he can do anything. I do, however, suggest that he can probably minimize his losses and possibly retrieve the situation altogether. He has to contend with the diversity of the rainfall; he must counter it by diversity of practice and diversity of crops. If cotton is ruined by rain early in December, the farmer may sow cotton again. In January it will be too late to resow cotton, and he must sow something else. What? I do not know, and so far as I could discover no one on the spot knows. If heavy and continuous rain occurs in February or March it appears to indicate good prospects for winter crops. At present they are not grown. I shall refer later on to the subject of variety of crops, but will here merely mention that in India, where the vagaries of the rainfall are greater than in South Africa, they are countered, and often very successfully, by the ingenuity and resource of the farmer in adapting himself to the circumstances of the season. To do this the farmer must understand the behaviour of his soils and know the requirements of many crops.

Insect Pests.—Insect attack is a menace to cotton in many countries. It certainly is so in South Africa, the principal enemies being jassids and three kinds of boll worm. They have been studied so little in South Africa that no one appears to be able to speak with authority on the matter. This omission is now being remedied. It is reasonable to suppose that the rapid spread of a new crop like cotton is likely to be followed by a great increase in the insects that thrive on it. This may well be followed by an increase in the enemies of these insects, till an equilibrium is established and nature readjusts itself. But it would not be safe to wait for the problem to solve itself in this way. The lines of action that seem to be indicated are:

(*a*) To avoid the concentration of cotton year after year on the same ground in large areas.

(*b*) To discover varieties of cotton which offer the greatest resistance to particular insects.

(*c*) To attack the insects themselves at the moment when they are most susceptible.

These matters demand much research and investigation, and every cotton-grower will hope that such may be undertaken. Some success has already been obtained in finding varieties of cotton immune to jassids, and there is no reason why the South African cotton-grower should be unduly pessimistic. The menace of insects is there, but there is every hope that it can be minimized. It affords one more reason why the farmer should not put all his eggs in one basket and trust to cotton as his only crop.

DIVERSITY OF CROPS AND FARMING PRACTICE.—I have already suggested that by introducing a greater variety of crops something can be done to retrieve the disasters due to excessive rain, to minimize insect attack, and to spread the seasonal risks over a wider field. Another advantage that may be looked for from this source is the better distribution of farm labour over the year. Having said so much, I may, perhaps, be expected to indicate what crops I would recommend. I need say nothing of maize, tobacco, or fruit, but experience in Western India leads me to suggest a trial of other crops that are commonly grown there in rotation with cotton under similar climatic conditions. Such crops are ground-nuts, sesamum, castor, chillies, and coriander in the summer; linseed, safflower, mustard, and rape in the winter; and many kinds of millets and pulses at both seasons. With facilities for winter irrigation various spices and condiments might be suggested. The agricultural practice of India is based on thousands of years of experience, and the adaptations that have taken place are very instructive. With each crop that I have mentioned many varieties have been selected, by a long and painful process of trial and error, as most suitable not only to particular soils, but also to particular seasons of the year. The skilled Indian cultivator knows the virtues of each of these local varieties, he knows the limitations of his own soils, he takes the rainfall as it comes, and makes about as good a job of it all as his very limited means will permit. In a new country this precision of detailed local knowledge is necessarily lacking. I do not say that Indian experience can be applied wholesale to African conditions, but I do think that in variety of cropping and in skilful adaptation of practice to circumstance Africa has much to learn from India, and that in this lies a vast field for investigation, both physical and economic. As things are at present the cotton-grower is often a mere cotton-grower, directly

at the mercy of the cotton season, the cotton insects, and the cotton markets. If his agricultural practice could be diversified and his operations put on a broader basis, he would be in a much stronger position.

I do not propose to discuss the question of the variety of cotton best suited to the locality. Much has still to be learnt on this subject. It is generally assumed that South Africa has facilities for growing cotton well in advance of Middling Americans. This may or may not be the case. Profits depend on quantity as well as on quality. In choosing what cotton to grow the farmer is often guided by the length of the staple rather than by the suitability of the variety to local conditions. He knows the former, while he does not know the latter. This has certainly contributed to failure in some cases.

In conclusion, I may state that in 1925 I saw no reason to modify the opinion that I had expressed three years previously. To my mind, the tract mentioned is very well suited to cotton-growing, and I believe that profitable cotton will be grown there in increasing quantities. The difficulties to be faced have been described, but there is no reason to suppose that they cannot be overcome. Much work remains to be done by the botanist and by the entomologist; and the man who works out a combined system of agriculture for this locality, in which cotton is the principal of many crops and not the only crop, will place the farmers under a load of obligation.

COTTON PROSPECTS IN PAPUA

BY

G. EVANS, C.I.E., M.A.

Empire Cotton Growing Corporation.

ITINERARY.

IN accordance with the instructions received from the Home and Territories Department of the Commonwealth Government, I left Brisbane by the S.S. *Morinda* on August 13 and arrived at Port Moresby, the capital of Papua, on the 19th. I was accompanied by Mr. E. Ballard, the Commonwealth Cotton Entomologist. Soon after arrival the cotton ginnery was visited and various official calls were made. On the morning of the 20th we left by sea with the Hon. F. Staniforth Smith, the Director of Agriculture, for Hisiu, some forty-five miles down the coast. We visited the cotton on the Hisiu Plantation the same afternoon. The next morning we visited Abu and rode on to Aroa, which we reached in the evening. The cotton on this plantation was inspected next morning and a cross-country journey made to Rorona in the afternoon. The following day was spent in going over the extensive cotton areas on this estate, and on Monday, the 28th, we examined the cotton at Lolorua, and from thence rode on to Kenesia. Here we were met by Mr. G. A. Loudon on his launch, and proceeded with him down the Galley Reach and returned to Port Moresby on the 25th. The next four days were spent at Port Moresby and its neighbourhood in going into the office records and in inspecting the country behind the town for some twenty miles inland. We left Port Moresby by the Government auxiliary ketch *Elevala* on the 30th, being accompanied by the Comptroller of Native Plantations, and visited Tavai Plantation the same day. There is a considerable acreage of cotton here, but it was suffering very severely from Pink Boll Worm. Samarai was reached on September 2 after a stormy passage, and the opportunity was taken to discuss cotton prospects with the District Officer and others. Samarai was left on the 3rd and Goodenough Island, one of the D'Entrecasteaux Group, was reached on the 4th. I was particularly asked to go into the possibilities of this island, and spent the greater part of two days there in consequence, and accordingly did not leave until the 6th. After calling at Buna on the 7th, and examining a large consignment of Pima cotton that had been sent

down to the coast from the Government native plantation at Mount Lamington in the Sangara district, Morobe in New Guinea Territory was reached early on the 9th.

Physical Features.

The territory of Papua comprises the south-eastern portion of New Guinea together with the Trobriands, Woodlark, D'Entrecasteaux, Louisiade, and other smaller groups of islands. The length from east to west is 800 miles, and it is 200 miles wide at its greatest breadth. The total area is over 90,000 square miles, of which 2,750 are made up of islands, the remainder being the mainland. Lying as it does within 5 to 12° south from the equator, the climate is wholly tropical. The interior is rugged and contains numerous high mountain ranges, the result being that the climate as a whole is very humid, with a high rainfall and a preponderance of cloudy weather. The western end of the territory is low and swampy for some distance inland.

The year can be roughly divided into two seasons—viz., that of the south-east trades from May to November, and the north-west season, which occupies the rest of the year and is the wetter period of the two.

There is a strip of country about 100 miles along the coast and extending for about forty to fifty miles on either side of Port Moresby, and going inland from the coast for fifteen or twenty miles, that possesses a drier climate which is in distinct contrast with most of the rest of the Territory. It is in this so-called dry belt that most of the short time available was spent in this Territory.

History of Cotton in Papua.

Sir William Macgregor, in his annual report of 1896–97, mentions that "cotton bushes are to be found in the gardens of the Upper Gira. It bears fairly well though uncultivated. It is not easy to believe that it is not indigenous." Time did not permit of a visit to this area, and such enquiries as we were able to make from officers who knew this valley did not throw much light on the subject. It is possible, however, that Sir William saw bushes of kidney cotton, as this seems to have been introduced into the coastal villages many years ago, possibly by native mission teachers or traders from Fiji, New Caledonia, or the Solomons. Odd bushes of this cotton are not uncommonly seen in various parts of the Territory, and particularly in the precincts of the villages. Trials with cotton were made in 1907, and a sample was sent from the Trobriand Islands to the Director of Agriculture, Victoria, who reported that "competent experts"

regarded it as good, marketable cotton, equal in character to Sea Island. A sample of Sea Island cotton, grown on the Government plantation at either Rigo or Katoa, not far from Port Moresby, was found in the small museum in the office of the Director of Agriculture. This sample was bright, lustrous, and just under two inches in length, and was of splendid quality, being very strong. Further experiments were made in 1908 with different kinds of cotton, amongst which were Caravonica and one or two Upland types. The report of 1911–12 mentions "that 337 acres were planted principally as a catch crop between coconuts, but that it is not anticipated that there will be any large increase in the industry except as a catch crop." For the year ending June, 1913, the export of cotton was 1,483 lbs., valued at £74.

So far as could be ascertained from the meagre records available, it was concluded that Sea Island cotton gave the best results, and over 1,000 acres of this variety were planted at Obu and other of the British New Guinea Co.'s plantations in the dry belt, although only a portion was apparently actually brought to harvest. For the following year (1914), the area brought to production was about 450 acres, almost the whole of it being grown in the dry belt, and 38 tons were exported to the value of £1,566. The 1915 figures were 105 tons valued at £3,400. With the outbreak of war, difficulties arose regarding the overseas transport and marketing of the crop, and its cultivation ceased, there being only five acres reported in 1917. Within the last two or three years, following on the recent high range of cotton prices, interest has again revived and considerable quantities of Upland seed were brought in from Queensland. The area planted in 1924–25 was 900 to 1,000 acres, but a portion of this was abandoned owing to floods and other causes. The crop is grown entirely on the plantation system and is practically all in the Central Division of the dry belt. The areas actually brought to harvest this season were roughly as follows:

Name of Plantation	*Division.*	*Acres.*
Laloki River	Central	—
Tavai	"	180
Obu	"	100
Aroa	"	100
Hisiu	"	60
Rorona	"	400
Lolorua	"	25
Patakalana	"	—
Huiva	Gulf	100
Kerema } Koaru }	"	50
Government Native Plantation, Buna District	"	say 25
	Total ..	.. 1,040

I saw practically all the cotton areas in the Central Division, but time did not permit me to visit the Gulf Division, where report stated that some good results were being obtained on the cotton plantation at Huiva. Neither for this reason was I able to visit the Government native plantation at Mount Lamington behind Buna, but I examined seed cotton from this place that had been sent to Buna for shipment.

Condition of the Crop in the Central District.

A brief account of the cotton crops actually inspected in the so-called "dry belt" may prove of interest.

At Hisiu Plantation the cotton was planted about half a mile from the beach behind a belt of coconuts. The land consists partly of a light loam of coralline formation, and here the cotton is somewhat tall and appears to have suffered at an early stage from some insect attack, possibly Heliothis, which resulted in the removal of the first crop of bolls. Part of the field is more low-lying and consists of somewhat heavier soil, and in this portion the crop suffered from waterlogging during the exceptionally heavy rains of April and May. At that time 30 inches of rain fell in six weeks instead of the normal 7 or 8 inches. The land is newly cleared scrub, and had been planted with young coconuts last year at the usual spacing, 30 feet by 30 feet. Cotton is being utilized as a catch crop with the idea of bringing in some revenue until the young coconuts are more advanced towards the bearing stage. The harvest was about two-thirds completed at the time of the visit, and the top crop that remained was naturally somewhat off quality, suffering from Pink Boll Worm, stainers, and the subsequent boll rots. Nevertheless, the pickers, who were partly casual labourers from a native village close by, and partly indentured boys, were picking surprisingly good grade cotton, and were averaging about 60 lbs. a day. The average yield was expected to work out at about 500 lbs. of seed cotton per acre, which is not at all bad considering the unpropitious season. The variety was mixed Upland American seed, having been obtained from Queensland. At Obu, which is about six miles west of Hisiu, some 75 acres were planted in January and February, the seed being similar. The soil consists of a shallow, stiff, red clay overlying coral rock which obtrudes on the surface in places. This land had failed to grow coconuts, but had, it was said, in previous years produced heavy crops of maize. The crop was very clean, and the spacing, 4 feet 6 inches by 18 inches, was quite suitable, but the crop was most disappointing. The land is an old garden site and is full of disease, and the soil is probably

unbalanced and may be deficient in phosphates and possibly potash. An attack of Earias had deformed the young bushes at an early date, and an attack of "red-leaf" or "curl" brought on by jassid completed the debacle. Thirty-five acres to the east is a somewhat deeper soil of a lighter consistency, and practically 80 per cent. of the total crop harvested had come from this area. To the east of the house a further 25 acres had been planted in the middle of March in the same class of soil and was a complete failure, Leucanium Scale and Woolly Aphis being evident in addition to the other pests. The total crop was only 15 tons from about 100 acres, and there was little more to come.

At Aroa, which is about four miles inland and less than ten miles from Hisiu, an attempt had again been made to utilize an area which was unsuited for coconuts by planting cotton. In this case the land was low-lying and swampy and the area had been under heavy lalang and swamp grass, which had then been burnt off and ploughed by tractor in December. After one harrowing the seed was planted in January, and since the soil was heavy, black clay loam, it was probably still sour at the time the seed was put in and would have been in better condition if it had been fallowed for a few months previously and exposed to the sun and air. The crop had been properly planted and spaced and was very free from weeds, but, nevertheless, the following series of disasters appear to have overtaken it. Firstly, an attack of Tip Worm (Earias) occurred early on. Then in April the crop was completely defoliated, probably either by Heliothis or Prodenia. After defoliation the exceptionally heavy rains of April and May came, and the whole of the area except a small portion, which is more high-lying, stood under water for six weeks. After the surface water disappeared, the plants put on fresh leaves, which were promptly attacked by hoppers. The crop will barely average 200 lbs. per acre, and most of the cotton is coming off the small, high lying portion referred to above. A better illustration of the futility of planting cotton on heavy, badly drained land could not be desired. As one leaves the plantation to go towards the Cabody Valley, one crosses low, basaltic hills, and there is some well-drained land along the slopes of these hills that is probably very much better suited to cotton than the rest of the estate. The possibility of testing cotton on this area was discussed with the manager (Mr. Walker). The Borona estate is situated in the valley of the Aroa River, and is some ten or twelve miles from the sea. There are 2,000 acres under coconuts, part of which are just coming into bearing, the remainder having been more recently planted. There are altogether about

400 acres under cotton, the idea being to raise some revenue from this crop, whilst the young coconuts remained in the unproductive stage. The area of this estate is very large, and a portion of it, consisting of low laterite hills and a heavy, black soil flat, was formerly planted with sisal hemp which has now been abandoned. About 220 acres of this flat had been planted to cotton. It was originally under heavy lalang (Kuro Kuro) grass, with the remains of the old sisal plants growing through it. These had been cut out and piled in rows at regular intervals. After burning, the land was ploughed twice by tractor, harrowed three times, and the seed planted in rows, partly by drill and partly by hand. It would have been better if the land could have been fallowed for a few months before planting. As it was, the land proved too heavy and low-lying for cotton, and waterlogging occurred during April and May. Here also the rainfall appears to have been abnormally heavy at this season. The plants were small, stunted, and unhealthy in appearance, suffering from "rust," caused apparently by jassids, whilst boll rots and Pink Boll Worm attacks were also evident. This crop is, therefore, most disappointing.

A small plot of 5 acres planted between young coconuts on an adjacent plot on somewhat lighter and better drained land was growing better, but was also suffering generally from boll rot. The seed used for planting this block had been sold to the plantation as selected Sea Island, but proved to be merely Mixed Upland seed similar to the rest of the cotton on this estate. This crop was not planted until April, which is probably a good deal too late. On the other side of the estate there were 175 acres of first-year ratoon. The seed had been planted the previous year, and part had been ratooned to the height of 8 inches in January and the rest in March. Although the crop was not good, it was better than on the rest of the estate. The land in this portion is good cotton soil and consists of about 2 feet of medium to sandy loam, with a good subsoil drainage of sand and fine gravel. The cotton was planted in four rows between each line of coconuts. The latter are now five and six years old, and are really too far advanced to permit of further continuance of this system. The ratoon cotton was also suffering from Pink Boll Worm and boll rots, and was of rather poor grade in consequence. It is very doubtful whether cotton will thrive on the heavy, black clay soils, but it should do well on the alluvial loams along the river, and a good many hundred acres of this class of land apparently exist in this valley that are at present entirely uncultivated, being kept under grass by the natives for use as hunting grounds, and burnt

off for this purpose each year. The rainfall at Rorona averages, as a rule, about 50 inches, but this year was over 60 inches. I formed the opinion that Sea Island cotton would be well worth trying on the alluvial loams, as I have seen good crops of this variety raised under very similar conditions of soil and climate in Fiji. Upland cotton was being tried at Lolorua, about ten miles further inland and separated from Rorona by a low range of hills. The manager's wife (Mrs. Jewell) had planted about 12 acres in newly felled scrub and had taken the greatest amount of trouble to keep the land clean and give the cotton every chance. The land is well drained and the soil a good chocolate loam. The plants were growing luxuriantly and covered with bolls, but practically every one of these was infected by boll rots, and unless a prolonged spell of dry, sunny weather sets in, it seems doubtful whether the crop will come to anything. Three tons of seed cotton were reported to have been picked off this plot. From appearances, it would seem that Lolorua is really on the edge of the dry belt and gets a good deal more rain than Rorona. It is a rubber plantation, and Para rubber and cotton are not usually associated with similar climatic requirements.

The Tavai Plantation is situated on the coast some thirty miles to the east of Port Moresby and is an old sisal hemp plantation, most of which is at present in an indifferent state of cultivation. Seventy-five acres of Durango cotton have been planted on newly cleared scrub some two or three miles inland. A little beyond this is an area of abandoned standover cotton, and then comes about 110 acres of ratooned mixed Queensland Upland cotton. The soil is a brown or dark grey loam, well drained, and of basaltic origin. It appeared to be a useful type of cotton soil, and this was borne out by the fact that the plants were growing in a very healthy manner and that there were no signs of the "red leaf" or "rust," which was so evident on some of the soils in other parts of the territory, and which is often an indication of some plant-food deficiency.

The crop is, nevertheless, a very poor one, and the manager only expected to get 4,000 lbs. of seed cotton from 175 acres. Such seed cotton as I had the opportunity of examining was, in addition to low grade, very badly stained. The cause of the damage is the Pink Boll Worm, and I have rarely seen a crop so utterly ruined by any pest. Every one of the few bolls that remained on the bushes was riddled, and the wild hibiscus bushes which occur here and there were also badly attacked. Enquiry elicited the fact that cotton had first been planted three years ago. The abandoned bushes of this crop were noticed growing amongst the grass, since no attempt had been

made to clean up the crops at the end of each year and thus to try and establish a "dead" season. The result has been that the pest has had a free run for three years and is now present in incredible numbers. It is hoped that this example will serve as a severe warning to others contemplating cotton-growing of the evils that are likely to result from a neglect to observe the most ordinary precautions. The only way to treat Upland cottons in the Tropics is to cut out the crop by a specified date each year, sacrificing, if necessary, a portion of the top crop. The debris must be burnt and a dead season of about three months should be established, during which there should be no cotton for the pests to feed on and so carry over until the succeeding season. This procedure is absolutely essential in any area where an outbreak of Pink Boll Worm has occurred. If neglected, it is only a matter of two or three years at most before cotton-growing will become quite unprofitable. In the case of Tavai, the only thing to be done is to cut out and burn all the existing cotton and the neighbouring hibiscus, and avoid planting for a couple of years or so.

Cotton Prospects in Other Parts.

I had not time to visit the Government native plantation at Sangara, twenty-five miles inland from Buna, but examined a consignment of Pima cotton from there. This cotton was of fair length, but a good deal of it was stained, weak, and off colour. I understand that this area is a wet one with a rainfall of about 120 inches or more. It will be very surprising, therefore, if Pima or any Egyptian type of cotton will stand up to these conditions, and if cotton is to be grown by the natives it will possibly be better to try Sea Island, or probably better still, kidney cotton, as the latter resists wet weather conditions better and is not so exacting in its requirements as the Sea Island variety. It would probably be more satisfactorily harvested by the local natives, who are naturally, at present, entirely inexperienced.

A visit was made to Goodenough Island, one of the D'Entrecasteaux group. This island, which is more or less circular in shape and about twenty miles across, is remarkable in that it includes a mountain mass, the central peak of which is 8,000 feet high. There is some good land on the island and the area is fairly extensive in the neighbourhood of Wataluma Bay. Mr. J. Ryan has recently taken up an area of land here and proposes to grow cotton. A well-drained piece of land in the neighbourhood of the village of Lelelea was suggested as suitable. There are a few Caravonica cotton bushes in this village. No Pink Boll Worm was found, but stainers were very

numerous. This part of the island is to the north-west, and is consequently dry during the S.E. season. The climatic conditions are probably more suitable to Sea Island than to Upland, and a trial will be made of this variety by Mr. Ryan. Advice with regard to the method of planting and other details was supplied to him on the spot. Native labour on this island is intelligent, cheap, and industrious. If the experiment succeeds there is considerable scope for extension on the other islands of this group.

The Existing Organization of Agricultural, Experimental, and Demonstration Work.

No experimental work is at present being carried on by the Department of Agriculture. This Department consists of a Director, who is an administrative officer and has charge of other important departments of Government in addition to agriculture. There is also a small clerical staff. There are no scientific officers and no experimental stations. Several Government plantations exist, however, in which plantation crops such as coconuts and rubber are being produced on a commercial basis. Speaking in the modern sense, therefore, this Agricultural Department cannot really be said to function at present, since it is universally recognized that the ordinary duty of such a Department is research and experiment, to be followed in due sequence by the demonstration of any improvements that may be brought to light and standardized. What the Department requires, therefore, is one or more officers who have been well trained in scientific agriculture and have some actual experience of tropical crops, including, if possible, cotton, and who will be able to carry out really reliable experiments on these crops, and so produce results of actual value to private growers. Another want is an entomologist, since many of the problems are intricate and can best be tackled by the entomologist and the scientific agriculturist working together.

In addition, there is the Department of Native Plantations, which is the result of an interesting attempt that is being made by the local administration to improve the standard of native agriculture. This scheme, which is just being developed, is only beginning to function in two divisions as yet. The system adopted is briefly as follows. After a general survey has been made, certain areas are set aside as native plantations. These are to be somewhat numerous but small in size, the idea being that they should serve the native population residing within about a five mile radius. Any native who puts in two months' work during the year on a native plantation is

exempt from the poll tax of ten shillings. If a native signs on for a proprietary plantation, on the other hand, he has to pay the full tax in some divisions or half tax in others. Mr. G. W. Murray, the Comptroller of this Department, is endeavouring to collect a staff of European assistants, and has commenced operations in one or two divisions. An attempt is being made to teach the natives to grow commercial crops in addition to the foodstuffs which they already cultivate in the gardens round their villages. At present in the village community the women do practically all the work in these gardens once the heavy work of felling and burning the scrub and clearing the land has been performed by the men. It is now hoped to get the men to work on the production of commercial crops such as rice, cotton, cocoa, etc., since they have plenty of time on their hands and are now beginning to desire certain goods which they cannot acquire unless they earn money. In the Gulf Division a start has, I understand, been made with the cultivation of paddy, since the tract is very suited for that crop, and at present there is a large annual import of rice into the Territory to meet the needs of the plantation managers, who feed their indentured labourers on imported rice. It is naturally felt that an attempt should be made to produce this rice locally, and Government has established a small rice mill at Port Moresby to deal with the locally grown crop. In the Northern Division Mr. Murray has an assistant stationed at Sangara, twenty-five miles inland from Buna. This officer has charge of nine plantations averaging about 80 acres each, and the main crops that are being grown are cacao and cotton. The variety of the latter that has been selected is Pima, and seeing that the climate is very damp and has a rainfall of normally 120 inches or more, it seems unlikely, as mentioned above, that this variety of cotton in particular will prove a success. The only cotton that is at all likely to suit these wet conditions is kidney cotton, and even this should be experimented with on a small scale only at the start. Cacao and cotton are not crops that are grown in the same locality as a rule, since they require entirely different climatic conditions. Although the Comptroller of Native Plantations is dealing entirely with agricultural matters and can only settle his problems by actual experiment, yet this officer is not attached to the Agricultural Department, but is under the Government Secretary. In the event of the Agricultural Department being reorganized and strengthened, it would probably be preferable to concentrate all the agricultural activities of Government under one head and to attach this subdepartment to agriculture.

The most likely place for cotton-growing in Papua is in the so-

called dry belt east and west of Port Moresby, and there might be some possibility of getting the natives to grow this crop as soon as Mr. Murray's organization is complete in this division. Progress is bound to be very slow at first, however, since it must not be forgotten that the Papuan native is only just emerging from the Stone Age so far as agriculture is concerned. Iron tools are still a comparative novelty, and the country possessed no beast of burden before the coming of the white man. Even now the native usually looks upon horses or bullocks with a feeling of mistrust, since he does not understand anything about them. It is an encouraging sign that on one or two of the plantations the native labourer has been taught to manage horses, cattle, and mules, and in some cases to use the plough. It is perfectly obvious that if village agriculture is to be improved the native will have to abandon the methods of his forefathers and learn how to use a plough and to employ bullocks or mules for traction. This will be the first step towards raising him in the agricultural scale. I was very favourably impressed with his intelligence, and if some means could be devised of teaching him in a simple and practical manner I believe he would soon learn. Unfortunately there is no medium for communicating these lessons between the European Agricultural Inspector and the raw untutored native. There should be an intermediate class of demonstrators in the shape of skilled ploughmen who will actually be in a position to get into close touch and reside in each native plantation area. The best type of man for this work would be Malays or Indians. Until this native demonstrator class can be introduced, the present system is bound to show very slow results.

Experimental Work a Primary Necessity.

It is important at the present time that Government should have some place in this belt at which careful experiments on this crop can be conducted over a series of years. At present it is by no means certain that Upland types are in the end likely to prove the most suitable. Last year, it is true, some good results were recorded where the crop had been planted on the right class of soil, but this season, with one or two exceptions, there is no disguising the fact that the results have been rather disappointing, and many of the planters have become somewhat disheartened. This has been partly due to the fact that the plantation owners appear to have regarded cotton either as a catch crop for coconuts or else as a hardy crop, not exacting in its requirements, and therefore suitable for filling up odd pieces of land

that are either too barren or swampy for coconuts. This year's experience has taught its lesson, and it is now fairly well recognized that cotton will not grow well in heavy clay or on land inclined to be swampy. It likes well-drained medium loams of fair depth, whilst on some of the thin coralline soils it appears specially apt to become affected by "rust," usually associated with "hoppers." This is often a sign of some plant-food deficiency. It is said also that this season was exceptionally wet during the period the crop was flowering and bolling. This would naturally affect the out-turns, and certainly the percentage of boll rot seen was higher than is desirable.

If the Agricultural Department had been properly equipped and staffed, however, it would have had definite information on these points, and would have been in the position of being able to advise plantations or private persons who wished to try the crop. In such an event many of the disappointing results and a good deal of the loss that has resulted to private owners would probably have been avoided.

A table showing the rainfall and humidity records for the years 1923–24 and 1924–25 for Port Moresby, which was the only one available, is attached to this report. The humidity, it will be noticed, remains rather high throughout the year, and this is the case also with the temperatures, which are very constant. Whilst it is too soon to state definitely whether Upland cotton is or is not suitable to this area, it would seem to be wise to start experimenting with other varieties in case it proves a broken reed.

I consider that it is highly desirable that properly conducted careful experiments should be made with Sea Island cotton this year, and this variety should be thoroughly tested out against Upland. Mr. Murray is taking up a plot of land on the Laloki River about nine miles from Port Moresby, known as the Jail Gardens. In the absence of a properly equipped Experimental Station an area was provisionally selected here for an experiment with this variety. The best time to plant would probably be December, but later plantings might be tried at intervals of one month and two months respectively. Seed has been ordered from Fiji, where the climatic conditions in the dry belt are not unlike those here. A brief description of the general conditions required by this variety, together with some details of spacing and cultivation, was prepared and published by the local press. Sea Island cotton is not unsuited to plantation conditions, but much will depend on the care bestowed on the cultivation, and on the picking and grading. There should be no serious difficulty in this respect in Papua, since those of the managers and overseers whom

I met seemed to be very much alive to these necessities, and the Papuan labourer under their direction was picking a surprisingly good grade of cotton considering the somewhat high proportion of stained and rotted cotton that was present in many of the fields.

COST OF LABOUR.

Papua possesses an advantage so far as cotton is concerned, in that labour is reasonably cheap and not inefficient, and for the time being, at any rate, is not insufficient in quantity. It is the yields per acre that have been wanting this year. On some of the plantations indentured labour was employed both for planting, weeding, and picking. On others, village labour was employed for the picking, women and the bigger children working as well as the men. At Hisiu, village pickers were averaging 60 lbs. of seed cotton of good quality per day. They were paid the usual rate of one-third of a penny a pound. The actual cost of picking worked out at seven-sixteenths of a penny or less than a halfpenny a pound.

The cost of plantation labour of all classes is about £25 per annum. This covers the cost of recruiting, food, and wages. The cost of recruiting is £3 for a one-year, £6 for a two-year, and £9 for a three-year recruit. Labourers can only be signed on for a period of not more than three years.

Allowing for absentees, sickness, and other causes, the "all in" cost of efficient labour on 311 working days a year is about 1s. 8d. per working day.

GINNING AND BALING.

A local syndicate has erected a small ginning plant at Port Moresby, and all the cotton in the Territory with the exception of that at Tavai, which has its own plant, is brought in here to be ginned. The freight on seed cotton by schooner from the Hisiu beach, which is an important centre, to Port Moresby is £3 per ton.

The plant consists of one Dobson and Barlow 70-saw gin, 1924 model, with a delinting machine attached. When I first visited the gin it was not working well, mainly owing to broken saws. The lint contained a high proportion of neps and motes, and some of the fibres were "gin cut." Matters subsequently improved. The lint was baled in a Bijoli Hemp Press and filled by hand. The bales are neat and well covered, and average 240 to 250 lbs. each, being 19×14×3 feet 10 inches. Up till now little attempt has been made to grade the seed cotton, and better results would be obtained if the cotton were to be roughly sorted into even lots before ginning. Later on,

if the industry develops, it might pay to borrow a trained grader from Queensland for a month or two, as the ginning season here comes on when that in Queensland is nearing completion.

Conclusions.

1. There is a dry belt, extending about fifty miles on each side of Port Moresby and about fifteen to twenty miles inland, that should prove suitable for cotton. In normal seasons the rainfall is not excessive, and there is a suitable dry season for harvesting cotton.

2. The crop of Upland cotton during the past season was disappointing, due partly to abnormally heavy rains in April and May, but also due to lack of experience on the part of the growers, who often planted in the wrong soils and at the wrong time of the year.

3. The Agricultural Department is very weak at present. It has no experimental farms and no scientific staff, and was not, therefore, in a position to give helpful advice to those who were trying cotton.

4. The staff of the Department needs to be reorganized, and should be strengthened by the appointment of at least one scientifically trained agriculturist who has had experience of tropical crops, including, if possible, cotton. An entomologist is also badly needed. He should be required to devote his attention to the problems connected with economic crops.

5. In the event of such a reorganization being effected, it is suggested that the Native Plantations Section should be incorporated in the Agricultural Department, since it is obvious that all agricultural research, experiment, and demonstration work should be co-ordinated under one head to avoid duplication or overlapping.

6. Although it is too soon yet to say definitely whether Upland American cottons are best suited to the Port Moresby area, it will be advisable to try experiments with other types, and the indications are that, given the right soil and proper methods of cultivation, the Sea Island type may prove suitable. It is suggested that careful experiments be initiated with this variety, which also appears likely to do well on certain islands of the D'Entrecasteaux group. Kidney cotton also deserves trial, particularly for use on the Native Plantations.

7. The control of the seed supply is one that needs careful consideration by the Agricultural Department, who should assume absolute control of all seed coming into the country. The necessity for preserving the purity of any variety, and particularly Sea Island, by the establishment of pure seed areas, is a very important point.

8. If possible, measures should be taken to disinfect by heat or other means all seed issued for planting, with a view to controlling the Pink Boll Worm. The habit of standing-over the cotton from one season to the next has had disastrous results on at least one plantation, and every grower, therefore, will be well advised to try and establish a "close" season of three months with the object of keeping this pest under control.

ACKNOWLEDGMENTS.

I wish to acknowledge my indebtedness to the Hon. Staniforth Smith, Director of Agriculture, for his kindness, and for the information he has placed at my disposal. My thanks are also due to Mr. G. W. Murray, the Comptroller of Native Plantations.

I am deeply indebted to Mr. G. A. Loudon and to the various managers on the plantations visited for their extreme kindness and hospitality. They were always anxious to help me by all possible means in prosecuting my enquiries.

RAINFALL AND MEAN HUMIDITY TABLE.

PORT MORESBY.

Month.	*Humidity.*		*Rainfall.*		*No. of Rainy Days.*	
	1923–25.	1924–25.	1923–24.	1924–25.	1923–24.	1924–25.
July ..	95	82	0·23	0·52	3	8
August ..	68	78	0·14	0·11	3	3
September	58	78	0·10	0·19	2	5
October ..	70	79	0·44	1·84	2	8
November	67	76	0·76	2·91	2	13
December	64	71	1·88	4·82	9	12
January ..	73	75	7·14	3·56	14	12
February	78	79	13·71	3·63	18	12
March ..	74	79	2·49	10·54	9	14
April ..	81	82	23·44	10·98	15	19
May ..	83	82	0·01	3·02	1	12
June ..	81	82	3·41	1·08	5	5
	Mean 75	Mean 79	Total 53·75	43·20	83	123

BRISBANE,
November 3, 1925.

The two Reports by Mr. Evans on Papua and New Guinea have been submitted to the Administrations of the respective Territories for consideration and comment.

REPORT ON COTTON-GROWING POSSIBILITIES IN THE TERRITORY OF NEW GUINEA

BY

G. EVANS, C.I.E., M.A.

Empire Cotton Growing Corporation.

THE instructions received from the Home and Territories Department of the Commonwealth Government of Australia were to visit this Territory, after completing a tour of Papua, and to inspect and report on its cotton-growing possibilities. I was accompanied by Mr. Ballard, the Cotton Entomologist of the Empire Cotton Growing Corporation, who is attached to the Commonwealth Government. Mr. Ballard will submit a technical and detailed report on the cotton pests observed. In my own report, therefore, I shall only deal with this aspect of the subject from a general standpoint in so far as it affects the economic issue. In view of the very large size of the territory, its scattered nature, and difficulties of communication, it was manifestly impossible for us to inspect all the possible areas, more especially as our time was limited. Accordingly Dr. Bryce, the Director of Agriculture, who arranged the itinerary, quite rightly decided that it would be far preferable for us to inspect one or two of the most promising areas thoroughly, rather than to pay a series of hurried visits to a larger number of centres. My report, therefore, deals with the places actually visited, and for all I know there may be other areas in this vast territory with equal or better cotton-growing possibilities, but which will require to be opened out by roads or other means of communication before this crop can be produced on an economic scale. It must not be forgotten that a very large portion of the mainland of New Guinea is still unexplored, and its agricultural possibilities are, therefore, as yet unknown.

ITINERARY.

We arrived at Morobe from Papua Territory on the morning of Wednesday, September 9, by the auxiliary ketch *Elevala*. Here we met Dr. G. Bryce, who had arrived the previous day from Rabaul by the S.S. *Nusa*. Morobe was originally established as a frontier station

under the German régime. It is situated on a bare ridge and possesses a good harbour. The hinterland behind the station (there is no town) is extremely rugged and difficult of access. We left the same evening for Lae by the *Nusa,* being accompanied by the District Officer, Mr. J. H. Lukin. After a tempestuous and uncomfortable night Lae was reached the next morning. This place is the headquarters of a District substation, and is occupied by a Deputy District Officer and some native police. There is no village. It is situated at the head of the Huon Gulf, close to the mouth of the Markham River. After assembling our stores and arranging for carriers we started next morning (September 11) on a tour of inspection of this valley. In view of its interesting possibilities with regard to cotton-growing, a detailed description of this country will be given later in this report. It is sufficient to say that we returned to Lae on September 28, after spending eighteen days in the Markham Valley. We penetrated inland for a hundred miles, crossing the divide to the headwaters of the Ramu River, and altogether marching a matter of 250 miles in that period. We left Lae on the same day by the *Nusa,* and arrived at Finschhafen on the 29th. After a stay of a few hours we continued our journey to Madang, passing along the Macleay coast, which is remarkable in that, unlike most of the rest of the New Guinea coast, it is practically devoid of forest, and the hills and slopes for several miles back are grassclad. It has been argued that for this reason the rainfall must be lighter and that this tract is, therefore, a comparatively dry belt. Whether this is so or not I cannot say since no meteorological data are available, but it appeared from the sea that the land consisted of a series of raised beaches of coralline limestone, and it is possible that the shallow and hungry nature of the soil may be accountable for the absence of heavy forest rather than any actual deficiency in rainfall. In any case, the coast is very sparsely inhabited and would not, on the face of it, be a promising field for cotton-growing. Madang was reached on the 30th, and an opportunity was taken of discussing matters with the District Officer and his staff and the officials of the Expropriation Board. Odd bushes of kidney cotton occur in this neighbourhood, and there was a considerable consignment of this variety of seed cotton in store from two plantations on Kar Kar Island. This island is about forty miles from Madang, and like the latter has a heavy rainfall. Partly on account of lack of time, and partly owing to the inclement weather and the bad landing facilities on the island, it was not found possible to visit Kar Kar, but I understand that the Expropriation Board have definitely decided to give up cotton-growing, mainly for the

reason, as far as could be gathered, that coconuts are the main crop to be maintained, and that new developments and experimentation hardly came within the scope of the Board's legitimate functions. Madang was left on October 1, and bad south-east weather was met with in the Vitiaz Straits. After a severe tussle with the elements, shelter was eventually attained in the lee of Arōp (or Long) Island, one of the Bismarck Archipelago, where the *Nusa* remained weather-bound for the better part of three days. Arōp is a volcanic island of very recent origin. To the students of ecology it undoubtedly presents many interesting features. The soils on the flatter portions of the island, which is perhaps 300 square miles in extent, consist of volcanic ash and disintegrated pumice, and are, therefore, very porous. This class of soil does not usually appear to suit cotton. After further struggles with the weather, Rabaul was reached on Thursday, October 8. Here an opportunity was taken of looking up the old German records of cotton experiments in the excellent little library that Dr. Bryce has managed to get together. The cotton plots are at Rabaul, in the Botanic Gardens, on the Experimental Farm at Bita Paka, and at Toma, all in the Gazelle Peninsula. We left Rabaul by the S.S. *Melusia* on October 20, and after transferring to the *Morinda* at Samarai, arrived at Brisbane on October 30.

History of Cotton-Growing in New Guinea.

A study of the German records that have been collected by the Director of Agriculture in his office library, and which I was able to refer to, indicates that experiments with different kinds of cotton had been made for a considerable period by the former German Government. The earliest reference is in the *Tropenpflanzer* of June, 1905. It is recorded that eighty hectares of Sea Island cotton were under cultivation at Kurengakaul, but that the growth of the young cotton, perhaps on account of the prevailing wet weather, was somewhat backward, but the plants produced a heavy crop of bolls. Cotton experiments were also made on two native plantations, both these places being, I gather, on the Gazelle Peninsula. The Kurengakaul cotton was examined by the Vereinigung Sachsischer Spinnereibesitzer, who reported as follows: Sea Island character, staple 40 to 50 mm. Not so bright in lustre, and somewhat coarser than true Sea Island. Very clean and strong in staple, apparently free of trash. Selected for spinning the finest counts and worth 1·20 to 1·40 marks per half-kilogram. The Bremen cotton market valued this cotton as "very fine" Sea Island quality, worth 1·10 to 1·20 marks per

half-kilogram. The yields do not appear to have been satisfactory, for there is no further mention of these plantations, but in 1907 it is recorded that the mission at Herbertshohe (now Kokapo on the Gazelle Peninsula) sent a sample of cotton which was valued by the Bremen cotton market on November 20, 1906, as white and yellowish Sea Island cotton with true Sea Island staple, worth about twelve pence per English pound weight. This consignment was purchased by an outside firm at 1·25 marks per half-kilogram. The Colonial Agricultural Committee were, nevertheless, of the opinion that notwithstanding this exceptionally favourable valuation, the cultivation of cotton in New Guinea needed to be proceeded with cautiously, since the irregularity of the rainfall and the great difficulties with regard to sufficient quantities of native labour rendered the extension of cotton cultivation a matter of little prospect.

In the supplement to the *Tropenpflanzer* of 1908, it is mentioned that an experiment had been made with Caravonica cotton in the Botanic Garden at Simpsonhafen (Rabaul); on account of the appearance of "rust," the crop was not successful. In 1909 several small samples of Caravonica, grown at Kieta on Bougainville Island in the Solomons, were favourably reported on at Bremen. In 1910 it is, however, again mentioned that the Caravonica cotton in the Botanic Gardens suffered from "rust," and it is interesting to note that in the experiments that have recently been conducted with Durango (an Upland American type) in the volcanic ash soil both at the Gardens and at other places on the Gazelle Peninsula, this variety had also suffered severely from the disease. The cause is probably a plant-food deficiency, and this seems to induce a severe attack of hopper (jassid), which causes the characteristic "red-leaf" or "rust" mentioned by the German experimenters.

It is remarkable that in all these records no mention is made of kidney cotton, and since this cotton is so distinct in character, it is unlikely that its trial would not have been recorded if seed of this variety had been specifically imported for experimental trials. It is possible, therefore, that kidney cotton was already in the country before experiments were commenced by the Germans, and it may have been introduced originally by traders or mission teachers from the New Hebrides, New Caledonia, or Fiji. This variety is certainly the hardiest and most disease-resisting cotton under the humid conditions that obtain over most parts of the territory, and it is evident that the German experiments, so far as they went, indicated that the rainfall was too heavy and evenly distributed for the successful cultivation of the finer commercial types such as Sea Island.

The Markham Valley.

This tract of country presents most interesting features, and as it appears from many points of view to be the most promising area in the territory for the development of native agriculture and the production by this means of crops of economic value such as cotton, it merits a detailed description.

(a) *Physiographical Features.*—The area is really a "rift," although incidentally it has been utilized by the Markham River for a portion of its length as a convenient means of access to the sea. It is bounded on either side by high ranges of mountains which reach to an altitude of 12,000 or 13,000 feet, and exercise a profound influence on the climate of the valley plains below. For the first fifty miles from the sea its direction is north-west, but it then changes to a more northerly direction. The first twenty-seven miles consist of dense tropical jungles, being typical rain forest with the usual accessories of dense shade, lianes, creepers and epiphytes. At the village of Gabsonkek the character of the country changes and patches of forest are interspersed with open grassy glades. Across the Ilap River, which is about four miles further on, the trees become fewer and fewer, until, at the Wawin crossing, about forty miles from the coast, the country consists of flat, open grassy plains bounded by low foothills, which are also grass covered and entirely devoid of trees except in the beds of ravines. The country remains open and devoid of forest for about twenty miles or so, and the valley hereabouts must be twelve to fifteen miles across. On the right bank of the Markham, opposite the Wawin, a very large river called the Watut enters and is said to carry as much, if not more, water than the Markham itself. The Watut Valley, at its lower end at any rate, has large, grassy flats, and their area would seem to be almost as extensive as those of the Markham Valley proper. We were not able to visit this valley, of which comparatively little is yet known, but from such scanty information as we were able to collect, it was gathered that a portion of these flats are swamps or liable to occasional inundation. Pursuing our march up to the east side of the valley, we crossed the Leron, a considerable stream that emerges from the foothills about four miles on the right through a fine gorge. For another six miles the open treeless country persists, but at about fifty-eight miles the Atzera country is entered and then continues to the Markham crossing at seventy-five miles from the sea. The Atzera inhabit a compact piece of country which is covered with thin open forest interspersed

with grassy savannahs, and well watered by several small streams of clear water that issue from the foothills. The whole of the country between Gabsonkek, which is a village of the Laewomba tribe, and the Atzera lands is at present entirely uninhabited and forms a sort of "no man's land" between the two peoples, who were, until quite recently, in a state of chronic hostility. These grasslands are used by both tribes as hunting grounds for wild pigs and other game, and the grass is burnt each year for this purpose.

At seventy-five miles the Markham River, still a considerable stream with a very rapid and turbulent current, enters the "rift" from a narrow valley issuing from the high Finisterre ranges on the right. The height above sea-level at the point where the track crosses is about 1,100 feet. On the other side of the river the rift preserves its remarkable features, and a stretch of open grass country about six miles across and possibly ten miles wide occurs, after which one comes to the country inhabited by the Amaro people, who speak a similar dialect to the Atzera people. This district also consists of scattered trees interspersed with grassy savannahs.

The watershed between the Markham and Ramu waters is a few miles further on, about ninety miles from the sea.

Open grass flats persisted until the Ramu River was reached, and the country was similar to the stretch between the Leron and the Wawin on the Markham side, except that the soil was heavier, there were more indications of swamps, and the foothills were more heavily timbered. It is possible that these indicate a somewhat heavier rainfall. The height at the divide is about 1,350 feet above sea-level, as ascertained with the aneroid by Mr. J. H. Lukin, the District Officer, who was with us on this portion of the trip.

(b) *The Climate.*—No accurate information of the rainfall, temperature, and humidity are available, since it is only within the last three years that this country has really come under control. There seems no doubt, however, that the lower part of the valley has a different season from the middle and upper portions. The dense, heavy forest round Lae, and for about thirty miles inland has, I should imagine, a heavy rainfall, probably a good deal too heavy for profitable cotton production. In this region it would seem that the heaviest rainfall occurs during the south-east season—*i.e.*, from June to October. The depth of mud, the luxuriant vegetation, the amount of surface water everywhere visible, and the excessive humidity of the atmosphere encountered during our first two days' march, made it evident that a rainy season was in progress at the time of our visit. The dividing line between the two regions is somewhere about the

line of the Ilap River, which is four miles beyond Gabsonkek and rather more than thirty miles from the sea. From here upwards there are signs of a much drier climate, and it is believed that the majority of the rain falls during the north-west period. The Rev. F. Oërtol of the Lutheran Mission, who resides at Kayapot, the chief village of the Atzora, and who has lived for sevoral years in this part of the valley, was good enough to give me his views basod on actual observations. He is of opinion that in the Atzera country the north-west season is usually heraldod by the occurrence of a series of thunderstorms in November and December, a period known by the natives as the "little rains." In January high winds from the north-west blowing up the Ramu Valley and over the divide persist continuously. There is little rain and no dew, and this month, therefore, is usually very dry. February sees the commencement of the "big rains," which are abundant in March and April, and begin to tail off towaıds tho end of May. June, July, August, and September are usually dry months, although odd showers occur. This year, however, there was a good deal of rain in August and in the first half of September. Thus the rain in August, as recorded by Mr. Oërtel in his newly established rain-gauge, indicated 8·89 inches and 22 rainy days, but wo were assured by him and by the natives that this stato of affairs is absolutely abnormal, and this was backed up by the fact that owing to the wet weather tho natives had only boen able to burn off a portion of thoir grasslands, whoreas this operation is usually completed by August in normal seasons.

Thore is no record of the total annual rainfall, but it is obviously very much less than lower down tho valloy or in the ranges that bound the valley on oithor side. One peculiar feature of tho climate is the prevalenco of high winds. The occurrence of high winds from the north-west at certain seasons has been mentioned by Mr. Oërtol, and likewiso the prevalence of winds from tho opposite direction was very evidont during tho time of our visit. This was particularly the case in the treeless region in tho neighbourhood of the Loron and Wawin Rivers. The south-east wind usually started about 10 a.m., and increased in violence until late in the evening. This will certainly necessitate the establishment of wind breaks if cotton-growing is to be attempted. In the Atzera and Amare countries the violence of these winds is tempered by the existence of scattered trees which do much to break its force.

There are two other climatic factors that will need to be considered so far as cotton-growing is concerned. The first is the atmospheric humidity. No records exist on this point, but at the

time of our visit the air was very much drier after crossing the Ilap River. Even on these open grass plains, however, the wind was by no means really dry, whereas at Kayapot, which is in the foothills and sheltered by belts of forest, and also in the Amare country, the air struck me as somewhat more humid. It is, however, difficult to arrive at any definite opinion on this point, as the season seems, as stated above, to have been abnormal, and thunderstorms were also hanging about which probably had a local effect.

The other factor is the prevalence of clouds and the presence of early morning mists. The latter were more frequent at the time of our visit than is desirable for cotton. The high mountains on either side of the valley were almost continuously under cloud, and rain was frequently seen to be falling heavily up there. Although little or no rain fell in the valley or on the lower foothills, yet the cloud shadows accompanied sometimes by morning mists frequently came across these areas. June, July, August, and September will be the picking season in the ordinary course of events, and it is necessary that this period should be dry and have abundant sunshine if the cotton is to ripen properly and not suffer unduly from boll rot and other diseases. Here again, however, it is difficult to decide whether this presence of cloud in excess was due to the abnormal season or not, and the matter can really only be decided satisfactorily by actual experience. The necessity for reliable data is obvious, and it is satisfactory to note that the Director of Agriculture is arranging for the establishment of meteorological stations at one or two places in the valley. From the point of view of climate the extent of the country that is possibly suited to cotton cultivation would be from the River Ilap or a few miles on the Wawin side of it, to the divide, and possibly for some twenty or thirty miles down the "rift" on the Ramu side to the Garam Mari villages, a length of about eighty miles and with an average width of perhaps ten miles. Further investigations may disclose other areas in the valley of the Watut. Roughly speaking, perhaps a total area of 1,000 square miles may prove suitable climatically.

(c) *The Soil.*—A good deal of attention was paid to the character of the soils, and a man with a spade accompanied us on practically all our marches. The Markham Valley is very deceptive in appearance. To the casual observer it appears to be a vast alluvial flat. This is not the case, however. The so-called valley is really a rift, and the whole country is geographically very new and shows evident signs of recent uplift. The Markham and its tributaries have not yet had time to cut beds for themselves, and at present they are shallow,

turbulent streams flowing over the surrounding surface. In some cases they have actually built up a bed for themselves that is higher than the level of the surrounding country. The current is in all cases very swift. Considering the moderate volume of water they usually carry, their beds cover a very wide area since they are frequently changing their courses. The Manyang River near Kayapet, for instance, has a course which is three miles wide and flows in two or three channels. It brings down large quantities of stones, gravel, and coarse sand, and frequently bursts its banks, tearing out fresh channels and depositing large quantities of rubbish, thereby ruining much good agricultural land. The Ramu is another example, but in this case the stream passes through foothills of sandstone, and consequently alluvial deposits of sandy loam are beginning to form in the lower reaches of its course. The Markham itself is so swift-flowing and has such a steep bed that it has not yet had time to deposit much alluvium on its banks, and its flood plains are consequently covered with stones and layers of coarse gravel. To the casual observer, the vast plains of waving grasses will convey an impression of luxuriance and deep, fertile soils, but the hasty survey we were able to make showed that this was not really the case. Large fertile areas do occur, but equally large areas consist of shallow, stony soils which would probably not be worth cultivating, although they should eventually prove to be of considerable value for pastoral purposes. The land on both sides of the Leron River, for several miles in width, consists of gravel patches covered with a thin layer of soil varying from about 3 or 4 inches only to a foot or more in depth. There is no subsoil. The same state of affairs occurs on the banks of most of the other rivers in the upper part of the valley. Away from the river banks the soil often improves, but, generally speaking, the extent of good soil is larger between the Wawin and the Ilap than it is between the Wawin and the Leron. About a mile north of the Wawin, however, a stretch of exceptionally suitable soil occurs several square miles in extent which appears to be an old lake bed. Some of the soils are too heavy and clayey for cotton, and this is particularly so in the case of some of the areas we saw on the other side of the Amare villages towards the Ramu. In most cases, however, the soils appear quite suitable for this crop, being black, chocolate, or grey-coloured medium loams, with the good subsoil drainage that is so desirable for cotton. There are large areas of this sort of land with a foot to a foot and a half of soil that are worth trying for cotton, more especially as they are not deep enough for bananas, taro, yams, and other root crops, and so it is not likely to interfere with the native food supply. The

deep, heavy soils are usually denoted by a heavy growth of lalang or "blady" grass; heavy swamps carry cane grass (Saccharum) and a reed; soils of medium depth carry a heavy growth of lalang mixed with Kangaroo grass (Anthistiria); while shallow, stony soils carry sparse, short Kangaroo and a smaller annual species. The growth of these grasses affords a very good guide to the character of the soil. Sufficient was seen to indicate that when this valley is opened up and a land settlement is undertaken, as presumably will be the case, one of the first things to be done will be to make a careful soil survey of the whole area, since the character of the soil varies greatly and within short distances.

COTTON EXPERIMENTS IN THE MARKHAM VALLEY.

Long staple Upland cotton (Durango) was tried at two places—viz., Lae and the Leron River.

The Lae Plots are situated close to the civil station on the sea coast and on newly cleared land, and consist of about one and a half acres. One portion was planted in May and the first picking was just being made when I visited the place on my return about the end of September. The other plot was planted one month later, and was then in boll. In both cases the plants had suffered from waterlogging, except in one or two spots where the land was high and well drained. Possibly better results would have been obtained if planting had occurred towards the end of the wet season instead of at the beginning. Stainers (Dysdercus) were abundant on the newly opened bolls, but were being kept in check by constant hand picking, a method that is practicable in the case of small plots such as those. A good deal of boll rot was also noticed. Pink Boll Worm was not observed. Such cotton as had been picked was of excellent quality, being silky and strong, with $1\frac{1}{16}$ inches staple. I am, however, very doubtful whether Upland cotton, at any rate, is likely to succeed at Lae as the rainfall is probably too high, and I consider that it would be desirable at the present stage to concentrate on the drier parts of the valley.

The Leron Plots.—About eight acres of Durango were planted, the seed having come from Queensland originally. The land was virgin country that had been under grass for an unknown period. The grass was cut and the soil hoed to a depth of several inches, and the seed planted straight away. Three acres were planted on May 29 and another three acres on June 6, whilst two acres of pure line Durango were not planted until a week later. The plots were very uneven

and the soils were shallow, varying from rather more than a foot to a few inches only in depth. There is no subsoil, and the soil directly overlies waterworn gravel containing boulders of considerable size. On the deeper patches of soil the plants had made surprisingly good growth, considering that the crop had been obviously planted out of season, and had received no preliminary cultivation. Some of the plants were three feet or more in height, but on the shallower soils the growth was naturally much less. One remarkable point was that the plants were of good colour and showed no signs of "red-leaf" or "rust." The whole crop was singularly free of pests, the only one evident being a species of Earias which was attacking the leading shoots in places. No Pink Boll Worm was noticed, and boll rots were remarkable by their absence. The plants, in spite of their rather small growth, were loaded with well-developed bolls. On my second visit to the Leron on the return journey on September 25 the first bolls had opened and I was able to pick a small sample. The cotton was bright and clean, with a staple of $1\frac{1}{4}$ inches full to $1\frac{3}{16}$ inches and very strong. In every way a desirable cotton and of a class that has a practically unlimited market. The bolls were opening out exceptionally well and afforded clean and easy picking.

Dr. Bryce had had this area planted in a hurry in order to afford me a chance of seeing some cotton growing at the time of my visit, although he fully recognized that it would not be planted under very favourable circumstances. The experiment is interesting as it seems to indicate distinct possibilities for cotton of this class, if planted in the somewhat deeper soils that do occur over considerable areas. It also indicates that experiments should be conducted so as to determine the correct time for planting. It will be necessary to observe also the incidence of insect pests if the crop is planted earlier, as it is, of course, possible that the present crop may be coming into boll at a period when certain insects are undergoing a resting stage.

Further Experiments Required.—The present experiments are sufficiently encouraging to warrant an extension of the experimental programme with Upland cotton. This should include a trial of different classes of soil and time of planting tests. To this end a number of localities were roughly marked down in which considerable areas of promising cotton soils occur, and it is proposed to prepare half-acre trial plots on as many of these as possible. The number of plots will depend, naturally, on the staff that Dr. Bryce is able to spare for this work. It will be better to have a moderate number of well-conducted plots rather than a larger number than can be

properly supervised. Some of the areas that struck me as being especially worthy of trial are:

1. The large grass plain between the Markham crossing and the first of the Amaro villages.

2. The open savannah lands of the Atzora country, with lighter and shallower soils than can be utilized for bananas, taro, or other native foodstuffs.

3. The large belt of cycad country between Sangam and the Leron.

4. A belt of cycad and Kangaroo grass country between the Pomoi and Shangat Rivers.

5. The old lake bed about two miles from the right bank of the Wawin.

6. The country on the left bank of the Wawin.

7. The foothills between the Safeh and the Marianpopo Rivers.

It is important to get the land roughly cultivated at least two months before planting if possible, so as to give the soil a chance of weathering before the seed is planted.

With regard to the time of planting this can only be found out by actual experiment, as we have not yet sufficient knowledge of the annual rainfall or its distribution. It might be possible to arrange for plantings at the end of December, at the end of January, or early in February, and again in the first half of March. If experiments on these lines can be introduced with Durango, some satisfactory data should be secured and an idea of the average yields per acre obtained. Until this factor is known it will be unwise to launch out on cotton-growing on an extensive scale.

Native Cotton.—Occasional bushes of a species somewhat resembling kidney tree cotton (*G. brasiliense*) were noted at various villages in the valley. At Monum, in the wet belt, the cotton looked unhealthy and was inferior. In the Atzora and Amare countries many villages have a few bushes growing near the houses, usually only partially cultivated, and in many cases of considerable age and in a state of neglect. The seed of this cotton was, it is said, originally introduced by two Germans fifteen years ago. At Kayapet, the chief village of the Atzera, one of the inhabitants had actually attempted to cultivate this cotton on a field scale. The soil selected was a deep medium loam with good underdrainage, and the plants, which were about eight months old, had grown into big bushes 9 or 10 feet high in places. A careful examination was made of these plants, and it was noticed that there was an obvious segregation into two main types. One type that predominated resembled the true kidney cotton in all respects. It is a strong-growing, woody plant, with a

tendency to put on much vegetative growth and with a large amount of leaf. The flowers are large and bright yellow with a dark red spot at the base of each petal. The seeds adhere together as in true kidney cotton, and the bolls are long, narrow, and pointed, and are all three-locked. The other type is much more slender, with a single main stem and an erect, open habit. The fruiting branches are shorter, and the leaves are fewer and smaller than in the other type. The bolls are not so long and narrow, and four locks are common. The flower has no red spots on the petal, and the seeds are free in the ripe boll and do not stick together as in kidney cotton. The seeds in both are naked and black, and in both the bolls hang downwards when nearly ripe, and this feature, together with the large bracteoles, and the fact that the ripe capsules do not dehisce widely as in Upland cotton, serve to protect the fibre from stain during wet weather. The free-seeded type is much earlier in ripening than the other, which is late in maturing, like true kidney cotton, and which it, in fact, closely resembles. The fibre in both cases was long, being $1\frac{3}{16}$ inches to $1\frac{1}{4}$ inches in length, but the early type seemed to have a silkier finish and a slightly higher ginning percentage. Thirty-one plants of the early type were selected and labelled, and the rest of the plants were cut out and the owner compensated. Arrangements were made to have the cotton from each of these plants picked separately, and it is proposed to plant the seed from each on a special plot at this village in the coming season. It is possible that systematic breeding on this type may result in the isolation of a useful cotton specially suited to local conditions, and in any case it should prove a type to have in reserve in case the Upland cottons do not eventually prove satisfactory. In this connection also I have discussed with the Director the desirability of testing Sea Island cotton, and this matter will also be considered as soon as the necessary staff and other details have been satisfactorily arranged.

It was noticed that all those native cottons were singularly free from pests. Only one case of Earias attack was seen here and no stainers were noted, although an Eriodendron tree not more than 200 yards or so away was covered with Dysdercus at the time. The green bolls of these cottons, it was noticed, stained the fingers a deep brown when burst open, and it is possible that the sap contains some substance that acts as a repellant to certain of the common cotton pests. The matter struck me as being of considerable interest and importance, and it is hoped that the Director of Agriculture and his staff will be able to carry on some work on these lines.

Need for Trained Staff.—In order to carry out properly an experimental programme such as has been outlined above, it will be necessary to recruit an officer who has been trained in scientific agriculture, who has some knowledge if possible of cotton as well as other tropical crops, and who is also well versed in the principles of plant breeding. In the event of his appointment, a suitable place for his headquarters would be in the Atzera country, and a likely site was noted near Sangam for the establishment of a small experimental farm of fifty acres or so. Such an area could be leased for a series of years from the natives at small cost and with little inconvenience to them. Sangam is more in the centre of the valley than Kayapot, which is under the foothills, and probably experiences more humid and misty conditions in consequence. Sangam would also be a more convenient centre from which to supervise the trial plots which, it has been suggested, should be established further down the valley in the uninhabited tract.

Population and Communications in the Markham Valley

The population is concentrated chiefly in the upper end of the valley and within or adjacent to the area that is proposed for cotton. There are a group of tribes here all speaking similar dialects and able to understand each other. A rough estimate of their number is as follows:

Atzera	8,000
Ongar	2,100
Amaro	2,800
Yaros	1,500
	14,400

or approximately 15,000 in all. As a race they are intelligent, and have a distinct agricultural bias. They have only recently come into contact with the white man, and are suspicious lest he should try to take their land away for plantations. On the other hand, they are beginning to feel the need for cash, which they now require to enable them to purchase some of their newly-felt wants such as knives, axes, lava-lavas, etc. If handled intelligently and with care, they will most probably settle down to the production of economic crops such as cotton, in addition to cultivating their own food crops as they do at present. In other words, the system of cotton production adopted with such success in Uganda, where the native-grown crop after a period of less than twenty years is now worth between two and two and a half million sterling annually, might with advantage be

applied here. Under this system each native would cultivate his acre or half-acre of cotton and sell it to a Government agent for a guaranteed price on the spot. For the first few years this work should remain in the hands of the Agricultural Department, who would also have to undertake the ginning, baling, and marketing. Later on, as the industry grows, the matter could probably be left safely to private enterprise. It is interesting to note in this connection that the Atzera and Amare people do not go in so completely for communal cultivation as is the custom in other parts of the Territory, and, in fact, in so many of the islands of the South Pacific. On the contrary, each man has his own little area in a banana plantation, which is marked off at each corner by a dracæna bush or some other sign. There would seem to be much more chance of introducing a commercial crop such as cotton here than in other parts where cultivation is carried out by the village community as a whole, solely with the idea of producing sufficient foodstuff to meet its immediate wants. Under the latter system no man, naturally, provides more than his share of the necessary produce, because any surplus he should by dint of extra labour provide would simply become the common property of the whole community.

With regard to communications, there is the possibility of making a fair port at Lae. A road will be necessary for the export of produce, and work on this has already been commenced by the Agricultural Department, good progress having been made in cutting the trace The Markham is of little use for the transport of produce, as the current is very swift and its course shallow and full of snags and sandbanks. An idea of the rapidity of the current will be obtained when it is realized that the canoes by which we returned from Gabsonkek only took two and a half hours to negotiate thirty miles, a distance that had taken us two days of hard marching through the mud to accomplish on our inward journey.

Cotton Prospects in Other Parts of the Territory.

Brief visits were made to Finschhafen and Madang on the north-west coast of the mainland of New Guinea. At both places odd trees of kidney cotton were observed, and they were found to be remarkably free from pests. Pink Boll Worm is apparently absent in this part, and a singular absence of stainers was observed. Whether this is a seasonal matter or whether it is due to a dislike on the part of the stainers for this variety cannot be stated, but it is interesting that in most cases where bushes of this variety were found, both in this

Territory and in Papua, a notable freedom from stainer attacks was generally seen. It had been brought to my notice that Sea Island cotton was being grown on two plantations (Kalili and Kavilo) situated on Kar Kar Island, which is about forty miles from Madang. Weather conditions did not permit us to visit the place, but a consignment of about 300 bags of seed cotton was examined in the store at Madang. It turned out to be kidney cotton, and a large part of the seed cotton had been in store for eighteen months and was consequently damaged by rats and dust. The whole consignment also showed signs of weather stain, but no Pink Boll Worm was noticed. These plantations are at present under the Expropriation Board, and I learnt from these officials that most of the cotton came from the Kalili Plantation, where there were about 10,000 bushes growing on a ridge of black, volcanic soil close to the sea. The crop had been planted between young coconut trees by the Germans a good many years ago, and during the war had been neglected. The bushes had been pruned in 1922 and the soil cultivated between them. A crop had been harvested in 1923, and the ginned cotton had been sold to a local firm for 1 shilling per lb., and they had afterwards shipped it from Sydney and it had eventually been sold in Lancashire. The Board now propose to give up cotton-growing as the trees are too old and they do not, under existing circumstances, feel prepared to plant up fresh areas. Some of this cotton was good, having a staple of $1\frac{1}{4}$ inches to $1\frac{5}{16}$ inches, and being white and strong although somewhat coarse. The drag was deficient and the cotton was somewhat wasty, but this may be due to the indifferent conditions under which the crop was grown. The ginning percentage is rather low, and the cotton is rather difficult to pick as the capsules in this variety only partially open when ripe. Nevertheless, this should not prove a serious obstacle with cheap labour available, provided decent yields and a suitable market are obtainable. The rainfall at Kar Kar is probably very similar to that of Madang, which is given in the appendix. It will be noted that there is no long, dry season, no great variation in temperature, and that the humidity is very high. It is remarkable that any cotton should be able to grow and produce under these conditions, which are exactly the opposite of the generally accepted idea of a cotton climate. The officials of the Expropriation Board have promised to supply a 10-lb. sample of lint of this cotton for valuation and detailed examination.

In the Rabaul district experiments have been carried out during the last two years with Durango at the Botanic Gardens and at Bita Paka, about twenty-eight miles away. In the Gardens the soil

consists of a deep, porous, volcanic ash with no subsoil. Last season fair yields were obtained and some cotton of excellent quality produced. This year the crop is a failure. The plants were affected by a bad attack of leaf curl, or "rust," caused by a hopper (Jassid), which greatly retarded the crop. Such bolls as are now being produced are being very badly attacked by Pink Boll Worm, and the plants were also suffering from two species of scale. Various kinds of cotton were tried here in previous times by the Germans, and three or four years ago Caravonica and Sea Island cotton had been planted, but had apparently given poor results. The rainfall averages about 86 inches, and the humidity is again excessive. All these facts render the likelihood of cotton production on a commercial scale decidedly problematical.

A series of careful experiments had been laid down at Bita Paka near the wireless station. The land had been previously under heavy lalang grass, and consisted of about 14 or 15 inches of black loam overlying whitish-yellow volcanic ash. The variety was Durango. The crop had been planted in March and had made excellent growths in the first place. When the first bolls were ripening, however, the crop was suddenly affected by leaf curl, or "rust," as at Rabaul. Exceptionally heavy rain fell in August, and the whole crop had turned out a complete failure. The plants were found to be very shallow rooted, and in many cases curiously "clubbed." The tap root was absolutely suppressed in nearly every instance. It is possible that this state of affairs may be caused by some plant-food deficiency. The black soil was apparently very rich in humus, but is possibly unbalanced and may be lacking in phosphates and potash. It has every appearance of a good maize soil. Samples of the soil and subsoil were taken for analysis, which should throw some light on the matter.

A visit was also made to Toma, about ten miles from Kokopo in the foothills, and some 1,500 feet above sea-level. Here the existence of a road and the presence of two buying agencies for local products is stimulating the natives to agriculture to an interesting degree. The chief demand at present is for foodstuffs and vegetables, but several natives had also applied for cotton seed from the Department of Agriculture. Durango was chiefly being grown, but kidney cotton was also being tried, and in one case the owner had filled up the blanks of his Durango with kidney seeds. An interesting comparison of the two varieties growing side by side was thus made possible. The soil was somewhat similar to that at Bita Paka, but was shallower and on a newly burnt piece of secondary forest situated

on a ridge. The Durango was about two months earlier than the kidney, and the first bolls were just opening, the kidney cotton being in flower. The Durango looked healthy on the whole and had plenty of bolls, but even at this early stage these were showing serious signs of boll rot and will not, I fear, give much yield in consequence. Both types were shallow rooted, but the lateral roots were far more abundant and vigorous in the case of the kidney. The growth and yield of these kidney cotton plots at Toma should be closely watched as they may give interesting results.

Cotton prospects in the heavy rainfall country that exists over such a large part of the Territory are not, therefore, very encouraging. It would be interesting, however, to carry out further experiments with the kidney cotton with a view to finding out the best time of planting, the correct spacing and other details, since it seems to be the only variety that is at all likely to do even moderately well, and it may prove suitable for the native cultivators. Sea Island might be tried on a small scale, but here again the rainfall periods are so frequent and the abundance of stainers and other pests so evident that it is doubtful whether it will succeed. I do not consider these areas suitable for Upland (*hirsutum*) cottons.

Conclusions.

The conclusions arrived at as the result of my tour may be summarized as follows:

(*a*) The most likely place in the territory for the growth of Upland cotton is the Markham Valley. In other places the climate is unsuitable on account of the heavy and evenly distributed rainfall and the high atmospheric humidity. Cotton experimental work should, therefore, be concentrated in the Markham Valley, which further seems particularly suitable for the development of a native-grown crop.

(*b*) The preliminary experiments made with Durango are sufficiently encouraging to warrant further experiments on a more extensive scale, especially with a view to ascertaining the best time to plant and to test the various classes of soil.

(*c*) The unknown factor at present is the climate, of which no records are as yet available. It will be necessary, therefore, to carry out experiments in the first place, and the issue of seed to natives or others on a large scale will be inadvisable at present. The most suitable variety has yet to be determined, and the proper time of planting, the best soils, and other details have all yet to be investigated.

(*d*) Selection work should also be carried out on a species of native cotton, which holds out promise of proving a useful substitute in case Upland cottons prove after due experiment to be unsuitable. This work should be kept quite distinct from that on Upland cotton. At a later stage it may be worth while trying Sea Island.

(*e*) The staff of the Agricultural Department needs strengthening by the recruitment of an officer for this work. He should have been trained in scientific agriculture, possess a knowledge of tropical crops, and if possible cotton, and should be well-grounded in the principles of plant-breeding. His headquarters might be at Sangam in the Atzera country, and he should have there a small experimental farm of about fifty acres and a small plot at Kayapet for the native variety.

(*f*) As the Pink Boll Worm is at present absent from the Markham Valley every effort should be made to keep this area clean. The issue of cotton seed for planting should be completely controlled by the Director of Agriculture acting for the Government, in order to effect this, and no seed should be allowed to enter this valley until it has been efficiently treated.

(*g*) The other areas in the territory appear to be too wet to hold out much prospect of cotton-growing on a large scale, but it is worth while conducting experiments with the kidney cotton variety on the Gazelle Peninsula with a view to its cultivation by natives.

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METEOROLOGICAL RECORDS.

Month.	Average Rainfall (Inches.)	Average Number of Wet Days	Temperature. Mean (Maximum).	Temperature. Mean (Minimum).	Humidity.
RABAUL:					
January	15·52	20·7	89·3	73·0	79
February	10·27	16·2	89·9	73·1	79
March	10·52	18·5	89·3	72·6	79
April . ..	9·24	18·0	90·0	72·8	79
May	5·67	12·8	90·2	72·7	79
June	3·58	13·1	89·4	72·4	79
July	3·91	11·8	89·2	72·0	75
August	3·75	11·3	89·3	72·0	71
September	3·33	12·3	91·2	72·4	70
October	3·98	11·1	91·7	72·4	69
November	6·52	16·1	91·2	72·4	74
December	9·88	16·2	90·1	72·7	77
Total (average of 10 years)	86·17	178·1			
MADANG:					
January	11·95	18·2	88·0	74·3	80
February	13·63	17·0	87·5	74·1	80
March	17·59	19·4	86·7	74·0	80
April	17·64	19·5	87·3	74·0	83
May	16·07	19·2	87·4	74·2	82
June	14·32	17·9	86·9	73·7	81
July	6·62	13·9	86·7	74·3	81
August	3·45	7·1	86·9	73·9	77
September ..	5·43	7·6	87·7	74·2	79
October	12·19	15·9	87·2	74·1	78
November	13·59	16·4	87·7	74·2	79
December	13·82	17·8	87·7	74·3	79
Total (average of 7 years) ..	140·30	189·9			

BRISBANE,
November 3, 1925.

THE PRINCIPLES AND PRACTICE OF YIELD TRIALS

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SECTION II.—PRACTICAL CONSIDERATIONS AND PROCEDURE

The eye of the munshi does not see how the wheat grows.

"*Is this the jungle?*" *said the jackal.* "*Nay,*" *quoth the kite,* "*this is the pandit's garden.*"—THE WISDOM OF ALI, THE SON OF GUGU.

§ I.—CONSIDERATIONS OF POLICY.

IN Section I. we have endeavoured to present the more important statistical principles that find application in yield trials. It is our object in this second part to explore broad questions of policy, to appraise the agricultural significance of trials, and to examine procedure. Knowledge and experience concerning yield trials have come so preponderantly from cereal studies that we are under the necessity of basing our considerations largely upon these crops.

Those whose investigational interests lie anywhere in the broad fields of crop husbandry hold a difficult position. They must try to keep abreast of advances in the sciences it is their task to apply. The refinements and statistical aids dealt with in Section I. represent the adoption of scientific method into agricultural study. But they are also compelled to keep their eyes on the great objective of applied crop science, which is to augment by every possible means the value of the national crop output. Accordingly, in writing upon practical considerations, we propose to depict at the outset the agricultural background against which yield trials should be viewed.

Endeavour to increase the national crop output must be concerned, broadly, with the practices of husbandry and with the crops that are grown. Only by examining these two matters for any country or set of circumstances is it possible to gauge the agricultural significance of yield trials. Not infrequently, national crop output is very sharply limited by factors which formal yield

trials cannot appropriately measure. In some wheat areas rust is an overwhelming determiner of yield. There, all efforts should be concentrated on finding or making rust-resistant forms, and for a number of years accurate formal yield trials are not needed. A seed supply in which wheat and barley are about equally mixed, or the sowing of the wretched grain remaining unconsumed at the end of the season, are defects in certain very backward countries. In such a case the organization of a seed supply, using existing varieties, will count for more than a demonstration of inter-varietal yield differences. Irrigational improvements, drainage, security, and many other matters, may deserve priority of attention over any formal investigation. There is no need to amplify these considerations. Their exact form necessarily reflects the circumstances of any particular area. But in no case should they be overlooked. They remind us that yield trials are not inevitable. There may well be circumstances, especially in developing countries, in which formal trials may be entirely omitted, and all effort concentrated on fundamental reforms. In modern life there is great play for a form of "organizing" which consists essentially of systematizing and labelling. One's attitude towards it may well be, "organize when you must and as far as you must"; not, "when you can and as far as you can." A similar spirit may well inform our attitude towards the institution of refined yield trials which are necessarily costly and laborious. It is salutary, when trials are in contemplation, to ask, and try faithfully to answer, two questions. First, Are the projected trials likely to afford such information as will promote increase in the crop output, having full regard to all the agricultural circumstances? And next, Are the trials framed on the simplest lines conformable with the precise requirements? Better no trial than an inadequate or supererogatory one. It will be patent that these questions can only be answered through some fair acquaintance with local conditions of output, demand, and husbandry. And we venture to suggest that the beginner in a new country should devote his first year to an examination of agricultural circumstances. Formal studies, like yield trials, may well wait upon the growth of his knowledge of what is required.

We have selected as the second great concern in attempts to augment national crop output, the crops that are grown. Broad choice of the most suitable crop comes to be made as a result of general experience. Definite trials come into their own when distinctions have to be drawn between variety and variety of

the same crop. Such distinctive differences are always of some importance. To the older and more intensive agricultures they are responsible for an important part of the small margin of visible improvement. It is probably correct to say that, in several countries at the present time, national crop output could most readily be enhanced by better utilization of existing varieties. Full national utilization of any crop necessitates, *inter alia*, that in every locality the "best adapted" variety should be grown. Now "best adapted" implies that which is most profitable to the producer. Remunerativeness of a variety is anything but simple. First of all, it depends upon yield per acre. Big yield differences as amongst the varieties of most crops outweigh all other considerations. But quality has also to be borne in mind. Quality itself is dependent on inherent biological characteristics of the produce, but its value to the producer turns on demand and other economic factors. The grower measures quality by what he is paid for it. There are yet other factors of varietal remunerativeness. For very late cereal districts in England, for example, earliness may, year in, year out, more than counterbalance, say, a 15 per cent. yield difference, which is only monetarily effective in the years of dry harvest. Small intervarietal yield differences, manifest in carefully conducted trials, are often unimportant in comparison with concomitant differences in quality, standing capacity, popularity, and other characteristics. It is thus seen that the planning, conduct, and interpretation of yield trials should always be informed by the spirit that figures of yield, while vitally important, are only a part of what it is desirable to know. Which is the most *remunerative* variety for any locality, and why? —that is the *whole* question.

§ II.—The Agricultural Significance of Yield Trial Results.

Statistical significance has been fully discussed in Section I. Nevertheless, it may not be out of place here to reiterate the warning that yield trial figures should be accorded no credence, nor even be divulged, unless accompanied by evidence of statistical significance.

A firm agricultural reservation must always be attached to yield trial results. The results of any trial are valid only for the precise cultural, soil, and climatic conditions of the trial. And small yield

differences, though statistically significant, have not necessarily an agricultural importance. We must follow out the implications of this reservation.

As a rule, a yield trial gives the average yields of a number of different varieties at least one of which is a "local standard"—*i.e.*, has been commonly grown and is quite familiar in local cultivation. In addition an appropriate "standard error," determined from the trial data, makes it possible to measure the statistical significance of the inter-varietal yield differences.

Some of the varieties will be found to differ from the standard by an amount which is not statistically significant. So far as the trial goes—and there is presumably no other evidence—such varieties are equal in yield to the standard. They must therefore be judged solely on characters other than measured yield. In cereals, for example, superiority of straw, of quality, of winter-hardiness, or of any other feature, may entitle them to further trial or to tentative adoption into cultivation. An apparently trivial characteristic may be important. Thus in oats white grain as opposed to black is a considerable recommendation. It is more popular among farmers and feeders, but no one is able to explain the fact. Without some specific superiority to the standard, these varieties, which merely equal it in yield, hardly deserve further consideration. In the great variability of all agricultural circumstances there always lurks the possibility that one such variety may in *some* locality have decided merit. The possibility can be proved only by arranging a trial in several localities. Widespread trials are costly, and in general no variety should be given extended trial without firm evidence of *some* superiority to the standard variety.

Judgment of all the characteristics of a variety involves close acquaintanceship with it. For this, study must be made at *every* stage of growth. Trials that consist simply of sowing, harvesting, and calculating are, as a rule, sadly imperfect. A detailed consideration of this matter will be found in § V. (*infra.*).

A certain number of varieties will probably differ from the standard by amounts that are small, but yet statistically significant. Of them some ancillary, non-yield, merit must be demanded before adoption in further trial or in cultivation. The demand will naturally not be quite so exacting as for varieties not significantly superior to the standard in yield. The actual magnitude of the least intervarietal yield difference possessing statistical significance depends on the form, extent, and carrying out of the trial. It is

controllable within fairly wide limits. The desirable magnitude of least-significant-inter-varietal-yield-difference—*i e.*, the degree of accuracy to be aimed at—varies according to circumstances. Primarily, it is determined by the extent of inter-varietal yield difference likely to be important in agricultural practice, having regard to quality and other non-yield characters. Now this is a matter for which no general rule can be framed. But as a guide we venture to offer an opinion in the case of English wheat. Improvements in English wheat varieties have gone on for very many years, so sudden and considerable betterment is not to be expected from new varieties. Probably, yield superiority over the standard variety, manifested in a trial and not exceeding 8 to 10 per cent., will be of no real agricultural importance unless accompanied by some qualitative superiority. Yeoman and White Victor wheats may be cited as an example. In an ordinary accurate trial on medium good land they might well display no significant yield difference. But the shorter, sturdier straw of Yeoman could not fail to attract notice during gusty weather. Accordingly, it might be inferred that Yeoman deserved trial in field cultivation at places where Victor was the standard variety. That Victor is a weak wheat and liable to sprout in the stook when harvest is wet are further facts making Yeoman yet more definitely commendable.

Finally, some varieties under trial may show big significant yield superiority over the standard. They deserve further trial even if possessed of no ancillary superiority as, for example, in quality of the produce. In English wheats differences of 10 per cent. and over may be suggested in this connection.

When, for any crop, in any set of circumstances, all these considerations have been weighed, it is generally possible to select some degree of trial-accuracy as appropriate and desirable. It may, for instance, appear suitable to aim at such precision that inter-varietal yield differences of 10 per cent. are statistically significant. By preliminary trial it must then be determined what number and form of replicated plot will give such precision; and what is their cost in land, time, and money. Available facilities will often inhibit the adoption of the theoretically desirable refinements. Compromise will then be necessary. Every case is a problem to itself, and it is well to resist the temptation to pursue faithfully the lines which have proved serviceable to someone else under some other conditions.

After these lengthy deliberations we are led back to the agricultural reservation with which this section opened. Season has,

as it were, "its own probable error." In commending a re-perusal of Section I. (pp. 138-146), we venture to suggest that repetition for three years is essential in every yield trial.

The same reservation points out that trial results are valid only for the cultural conditions and soil concerned. Many soils—local variants—and standards of cultivation are requisite to bring out *all* the characteristics of a variety. For that reason it is indispensable to try to arrange large "observation plots" in conjunction with formal trials. § IV. (*infra*) is devoted to a discussion of these plots, while in § III (*infra*) will be found an examination of the significance of "trial conditions." The faithlessness of small though apparently statistically significant yield trial differences must be recognized at the outset. It is salutary, in many cases, to lay out an exact replica of a trial on the opposite side of the hedge or at the other end of the field. In this diversion all beginners are recommended to indulge.

A plethora of varieties in general cultivation is very undesirable on many grounds. This fact should restrain all judgments of varietal merit as displayed in yield trials. Ancillary, non-yield (as measured by trials), characters are always important, and increasingly so the older and more intensive the scale of farming.

There is no universally best form or scale of yield trial; no *one* degree of significant difference at which all should aim; no *one* degree of varietal difference from the standard which should ensure further, extended, trial; and no *one* general rule of conduct for trials.

Picking the best variety for a locality is like picking a horse or a wife—every man must decide what he wants and then set out to get it.

In saying that trial results apply only to the soil actually occupied by the plots we have so far had in mind the probability that in a neighbouring field somewhat different results might have appeared. But the reservation goes much farther. It inducts us into the difficulties and obscurities of the great problem of varietal adaptation. Practice and experiment unite to emphasize how universal and pronounced a phenomenon this is. Even over an English county there is no one "best" wheat. Localities but a few miles apart may find most profit from two quite different wheats. In South Lincolnshire, Yeoman, Little Joss, Swedish Iron, and Squarehead's Master are recognized as respectively the best in adjoining close areas, which, with the same climate, have different soils. Some degree of varietal adaptation is exhibited by

all crops. Thus there is perceived to be, as it were, a major limitation to the agricultural significance of yield trial results. The fact lends support to the recommendation made in § IV. (*infra*) that widely scattered observation plots should accompany localized formal trials.

§ III.—Yield Trial Conditions and Field Conditions.

Upon the agricultural merits of a variety the farmer is final arbiter. Enough has already been said to show that even the best trials have a limited agricultural significance. But a succession of varieties, newly bred or newly imported from other places, cannot be showered on farmers "to see how they do in cultivation." A preliminary sorting out must be effected, and trials offer the only means. That in instituting, framing, and conducting yield trials there may be clear understanding of the ultimate possibilities to be expected from the results, we must probe the causes of limited agricultural significance. It is to be understood that in speaking of the limitations of trials the word is in no sense meant to imply defects. Defects in yield trials are remediable; limitations of agricultural significance are inevitable. Our concern here is to review these inevitable limitations. That cereal yield trials are selected as examples for this purpose strengthens the case. For in point of precision and proved value no trials can compare with the two forms much used for cereals which are described in §§ VIII. and IX. (*infra*).

Limitation comes first from the fact that the results of any trial are strictly valid only for the patch of ground the trial occupied. The soil of even a small district is usually "patchy." Extension of the trials to several places in the locality concerned suggests itself as a remedy. But accurate trials are too costly for wide extension.

Next is the fact that accurate trials must be on a comparatively small scale. There are certain features of all agricultural plants that become apparent only in large-scale working. In cereals, movement of the standing crop during tempestuous weather cannot be properly gauged from small plots. There are curious tendencies in certain wheats to be perceived only in bulk conditions. Examples are sprouting in the stook if harvest is delayed and wet, excessive brittleness of straw in threshing, and shaling (grain shedding) during cutting. The true seriousness of extreme earliness in early districts or marked lateness in late districts makes itself felt only

when a big piece of corn has to be handled. In six-row barleys capacity to regrow to a grain crop after heavy sheeping in spring may similarly be cited. Broad categories of limitation are almost implied by the very use of the word "trial." We may now leave them for more precise considerations.

High statistical reliability in trials is very closely dependent upon a good plant and high survival rate on all the plots. In consequence an extremely good tilth is usually prepared and sowing done with great care. For instance, in the chessboard trial the seeds are dropped one at a time into regularly dibbed holes, the surface being then lightly raked by hand. In spring barleys thus sown there may well be a 90 per cent. survival of plants at harvest. Almost every plant that survives grows well and makes a good contribution to the grain yield. In a typical barley yield trial on these lines, the seed rate being about a bushel per acre, the rate of yield was 56 bushels per acre, and the land was such that an ordinary field crop of 40 bushels would have been exceptional.

Perhaps the prime cause of limited agricultural significance in trials for which the seed is dibbed at regular intervals lies in the spacing. For chessboard trials of cereals a spacing of 6 by 2 inches is employed because of its great working convenience. In field crops of cereals the rows or drills are usually 8 to 10 inches apart, while the number of plants per foot is extremely variable. On a typical field it ranges from point to point in the row between 0 and 30, the average commonly being 9 to 14. Thus the chessboard spacing differs from field spacing, not only in average value but, what is more important, in that it is regular. A field crop is a vast aggregate of elements or plotlets having a whole range of spacings. This yield in the field is a complex function of yield at different spacings. And it has been demonstrated in a number of experiments that, while all varieties of a crop are affected in plant development and yield per unit area by spacing, they are not all affected in the same way. Thus it may happen that one variety crops exceptionally well in comparison with its yielding-capacity in the field, when grown at a regular spacing of 6 by 2 inches.

Many instances of spatial effects have been met. In all forms of trial and with every kind of crop, spacing must be carefully considered. The general rule is to adopt the happiest compromise between the demands of working convenience and the custom followed in field crops. When trials have to be made on an unfamiliar crop or under the comparatively unknown conditions of a new country, it is important to ascertain the spatial arrangements

favoured in local cultivation. Suggestions for a means of ascertainment have been made in the case of cereals.*

In the Strip Test, later described, ordinary field spacing is used. Where a sufficiency of seed and other requirements make this form of test practicable, it will be found to commend itself for crops in general. Its special features, apart from the spatial one, are considered in subsequent pages.

§ IV.—Observation Plots

We venture to suggest that observation plots are a valuable supplement to precision yield trials. They meet certain of the agricultural objections or, better, limitations, from which trial data necessarily suffer.

Observation plots imply plots of some ¼ to 1 acre in area, one for every variety under trial, sown and handled entirely in field fashion. They are for observation in the manner to be explained. To appreciate their function we may briefly review the features it is desirable a comparative "trial" of varieties should embrace.

Statistically significant yield data are the first requirement in a variety trial. They are to be had only from carefully planned and conducted formal trials. Because of inevitable soil inequalities and other circumstances, inter-varietal differences of less than 15 to 20 per cent. are not demonstrable by means of single plots. No amount of care in handling will overcome this difficulty. It is entirely unjustifiable to seek in single observation plots a source of reliable "yield figures."

It has been explained that certain plant characteristics, ancillary to "yield" (as measured by formal trials) in determining varietal remunerativeness, become apparent only from bulk handling. Bulk impressions, elusive in the small-scale trial, may often be gained from the larger observation plot.

Many types of soil—local variants—and many standards and methods of farming are required to discover the full merits and blemishes of a variety. Now expense renders impossible the wide repetition of accurate trials in a number of places. Observation plots in selected localities, supplementary to the accurate trial at one place, afford opportunity to study the varieties under a range of conditions. Such plots cost little in comparison with formal trials, call for no special skill, and are such as in many countries

* Engledow, F. L.: "A Census of an Acre of Corn," *Journal of Agricultural Science*, vol. xvi., April, 1926.

certain of the farmers will themselves undertake. The curiously local place limitations of some of our best English wheats are evidence of the need for observations upon trial varieties under a diversity of soil and other conditions. Formal trials, confined to one field, might well mask the merits of a variety inherently well adapted to the locality or some neighbouring locality.

If observation plots are sown and in every respect treated according to local field crop custom, they bring within the ambit of the testing such field conditions as are sometimes precluded from trials. This matter needs no emphasis here, as the nature of "trial conditions" has been discussed in § III. (*supra*).

The interest observation plots awaken in farmers must be counted among their advantages. It is sometimes sought to extenuate the publication of single yield figures by adducing this advantage. But the case can never be made good. If yield-figures are to be given, then in fairness to farmers and all concerned the complete series of plots should be duplicated. Duplication need involve no added expense, for it may be arranged by halving the number of varieties originally intended for trial.

In new countries even single plots of a few important varieties may strain the investigator's resources. Such countries drive home the maxim, "You must cut your coat according to the cloth." To those compelled to limit trials to single plots, careful observation on the lines of § V. (*infra*) may prove of much value. Statistical danger always lurks in single plots, but there is no reason why the investigator should run into it. Single observation plots are not often worth weighing at all; and never worth the weighing to the nearest pound that they sometimes receive.

Wherever trials are needed and facilities are reasonably good, reliable formal trials should be made. But whenever possible such trials should be supplemented by observation plots repeated in an appropriate number of places around the centre of formal trial. The kind of observation to be made is our next concern.

§ V.—Observations on Plots.

The case for supplementing yield trial figures by "observation" has already been argued. Its basis was the fact that handling produce in bulk and growings under diverse conditions could alone discover certain varietal features. In applied biology, unsupported numerical data may be misleading. And it appears desirable to submit the case for "observation" from the point of

view of the necessity for biological and agricultural interpretation of yield trial figures.

Yield trials are frequently connected with plant-breeding. Modern breeding is synthetic—that is, parents are chosen and their hybrid segregates selected, on the basis of specifically valuable features. Thus knowledge of plant characteristics, of whatever kind, of which relative yields of old and new varieties are reflections, is of great value.

In some trials statistical reliability is disappointingly low. Irregular loss of plants at an early stage may well be the cause. Simple causes, at any rate, will be disclosed by periodic observation. Simple, fundamental causes may also account for large inter-varietal yield differences. *Helminthosporium* attack in oats or barley is an example. One variety may be severely attacked. The reason may be simply that the seed came from a badly infected crop, not that the variety is specially susceptible. Ancillary observation and investigation may here be more informative than the final yield figure.

Year-to-year differences among varieties may be sometimes interpreted by simple observation. As an example a chessboard trial of wheats in two years may be cited. The wheats were Yeoman (Y), Squarehead's Master (S), and Rivet (R). In the first year winter conditions were good and the order of development of young tillers was that in which the wheats are named above. During winter in the second year the ground was at times water-logged, and there were two prolonged periods of frost. Yeoman developed very slowly, and entirely lost its early stage ascendancy of the previous year.

It was perfectly apparent to careful eye observation of tillering and general appearance that in a hard, wet winter Yeoman was, relatively to the other wheats, not adapted to ill-drained land. Such an inference concerning a wheat under trial is of much value. It serves not merely to interpret the final yield result, but to indicate the kind of soil on which the variety should or should not receive extended trial.

The ultimate purpose of trials is to determine the best adapted —*i.e.*, most remunerative—variety for a locality. Adaptation sums up the interplay of plant characteristics and local peculiarities of soil, climate, market, etc. A yield figure is a succinct recapitulation of the events of every day in the life of the crop. To understand varietal yield differences crop history must be periodically recorded. In these considerations is a *prima facie* case for study

of specific plant characters and for periodic observation. Available time naturally limits observation, but the number of varieties under trial should be commensurate with the facilities for observation.

No general schedule of observations can be laid down. To be able to place upon the final yield figures a biological and agricultural interpretation is the guiding aim. It is always informative to compare progress on trial and observation plots with the ordinary field crops of the locality. A plot cannot be gauged by standing at one end of it. To walk repeatedly over the land of a small-scale trial may disturb evenness of conditions. Large supplementary observation plots are, from this point of view, a great advantage. Eye impressions may be deceptive. Recorders should habituate themselves to critical care in settling a basis of estimation, and in ensuring the representativeness of their observations.

Formal "score cards" for field observations are apt to make examination perfunctory. A more or less definite but elastic schedule of observations does, however, focus the attention.

To watch the plots throughout life, studying their response to weather periods, and having always in mind possible pre-determination of the final yield, is essential and very profitable. Never be content with an unsupplemented yield figure, however high its statistical reliability.

§ VI.—As to Procedure in General.

Yield trials should never be instituted unless an examination of local circumstances suggests they are likely to bring definite advantage. Assuming this requirement to have been satisfied, we may now examine, generally, the procedure to be adopted. The object of yield trials is to show which variety of any crop is likely to be the most remunerative in the area concerned. Accordingly, the first phase of procedure must be a survey of the agricultural and economic factors which primarily determine the remunerativeness of the crop. This will suggest which of the varietal characteristics, in addition to yield as measured by formal trial, deserve particular study. Next must be considered the varieties available for trial. The commonest local variety will naturally be adopted as a standard. Varieties from neighbouring localities may well be included. Importations from other countries are often available. As a rule, before choosing the varieties for trial, at least one year of preliminary growing in observation plots is desirable. This will

ensure that effort is not squandered on the formal testing of clear failures. In the preliminary sorting out of varieties, perhaps more than in any other phase of yield trials, a famous military maxim should be remembered: "Time spent in reconnaissance is never wasted." Finally, there must be a reckoning-up of the facilities available. Sowing, cultivation, continuous observation, harvest, and storage must be provided for, over a period of at least three years. In accurate trials no operation may be allowed to wait on convenience; it must be done as soon as the right time arrives. Very often the secret of equalizing trial requirements and working facilities lies in reducing the number of varieties. For a constant outlay of time, land, and money four varieties can be given three times as much attention as twelve.

Localities must next be chosen for the formal trials and the supplementary observation plots. That locality of the whole area which best combines working convenience and representativeness will naturally be selected for the formal trials. One set of observation plots should, of course, be laid down alongside these trials. The *number and distribution of the other observation plots* will depend on local circumstances and resources. For observation plots local methods of cultivation and seeding should, as a rule, be followed. In the accurate formal trials the method of sowing, etc., may or may not be the same as in local field practice, according to the kind of trial adopted. But in either case accurate trials call for much circumspection, and we propose to discuss now certain of the more important considerations.

The degree of statistical reliability attained in any one form of trial is largely governed by the evenness of the soil. Really great uniformity of soil is nowhere to be found. But the most uniform stretch available should, *ceteris paribus*, be selected for trials. It is sometimes argued that field crops have to be grown on uneven soil, and therefore, to make yield trials representative of the field, they, too, should be on casually chosen, uneven soil. This is erroneous. Formal trials, as explained in earlier sections, can never be widely representative of all the conditions of the field. Their representativeness will not be augmented by merely pitching them on an uneven piece of soil. For "unevenness" of soil is of many kinds. But, most important of all, is the fact that unevenness of soil lowers reliability of result. Although a formal trial gives results strictly valid only for the patch of ground it occupies, its results are valueless as numerical results if they lack statistical significance. Precision should be a prime objective in precise

formal trials; the varying effects produced by the great irregularities of field soils may be partly brought within the scope of test by using observation plots. Subsoil must be examined with no less care than top-soil. In old, settled countries, local knowledge can usually be relied on in gauging the "evenness" of a field. But a beginner in a new country will be well repaid for the trouble of digging holes at regular intervals so as to select his trial land on subsoil character.

A year of preliminary cropping gives valuable information as to the characteristics of a site on which future formal trials are contemplated.

Protection of standing crops against birds and animals, and good facilities for storage of produce, must be ensured. More than one laborious trial has been ruined by crows taking out seeds, rabbits eating half-grown plants, and rats devouring stacked sheaves. Elephants are reported to have destroyed the plots on some African cotton stations. It is always well to try to foresee the possible extraneous difficulties of yield-testing.

Only the best obtainable seed should be sown. Germination failures and sickly plants from imperfect seed greatly upset reliability of result. If, in any case, goodness of seed is a point of intrinsic interest, it should be the object of a separate investigation. Source of seed is generally important. It may count for more than the small yield differences among varieties sometimes found in trials. For security, the seed of all the varieties under trial should be from at least two years' growings in one and the same place. In crops such as the cereals, where seed-borne disease is common, the seed should be inspected, and if necessary appropriately dressed.

Weeds must be completely kept under. Irregular treading of man or beast as between plot and plot is to be avoided, for on a fine, deep tilth this may induce serious irregularity of growth, which is inimical to reliability of result. No amount of mathematical exertion in arranging plots or elaborating results will undo the effects of bad husbandry.

Trials sometimes have to be confined year after year to a comparatively limited piece of ground. A rotation to keep up fertility and ensure cleanliness must be arranged in such a case. Permanent beds and permanent, marked paths are desirable. The site of a last year's path is sometimes visible on a trial bed, its disturbing effects being very patent.

The size, the number, and the arrangement of the plots in a trial are very important considerations. No general rules can be

stated. As explained in Section I., § 8, the standard error of single plot yield diminishes with increase in the size of the plot. But the rate of diminution actually found by experiment lags behind the theoretical rate. And it is generally accepted that $\frac{1}{40}$ acre is about the optimum size for ordinary field-scale trial plots of cereals. By lessening size, number of plots can be increased, but with small plots difficulties of handling—*e.g.*, drilling—are involved. These do not disappear until the plot size is so reduced as to make hand-sowing and hand-harvesting possible. And for purposes of description it will be convenient to recognize two broad categories of trial. These are "small-scale" trials, of which the standard form in cereals is the "chessboard" trial; and "field-scale" trials, of which the standard cereal form is the "strip test." §§ VIII. and IX. (*infra*) are devoted to an account of these two trials. Each has merits and limitations of its own; they are but two of many possible forms; but they have been employed with great success, and none better illustrate cardinal principles. Every investigator must design his own form of trial, seeking to make it the best compromise between statistical requirement and local circumstance.

Samples for qualitative estimation may be drawn from the produce of yield trials. It is, naturally, essential to make them representative. In many trials, especially cereal trials, heed must be paid to the water-content of the produce at the time of weighing.

It is fundamental to sound procedure that the trial plots, of whatsoever kind, be kept under close, critical observation from start to finish. Trial plots involve a dreary amount of routine work. But the performance of much of this work, instead of the delegation of the whole of it, makes for a close intimacy with all the varieties.

§ VII.—An Example of Small Observation Plots.

One of the greatest difficulties in breeding is the steady elimination of the many segregates obtained from a cross. Without elimination, commencing in the early hybrid generations, the growing bulk of material would soon outmatch even the best facilities. Small observation plots may be of considerable value for this purpose, and an account of such a set of plots will serve to illustrate certain practical points.

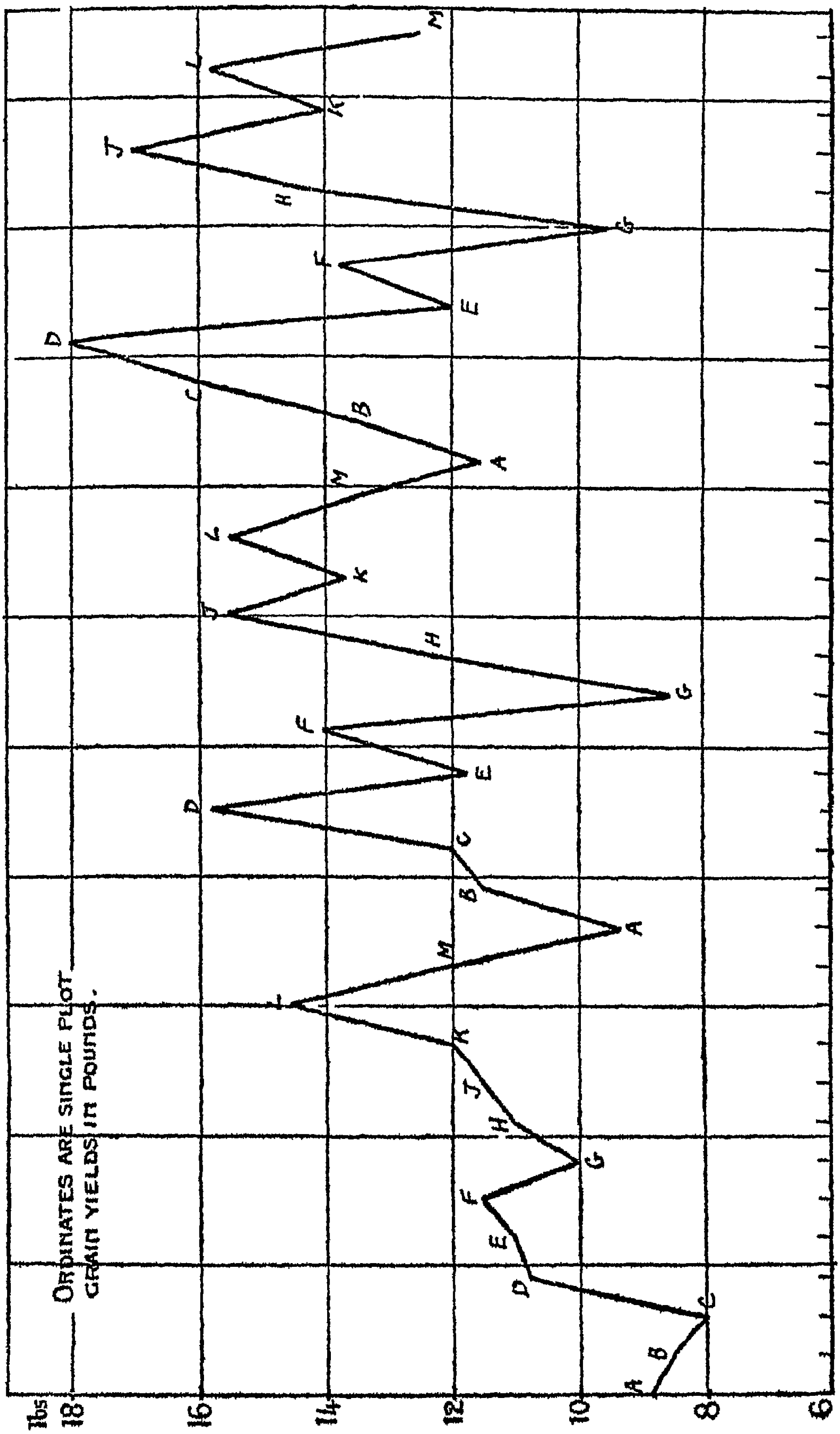
Several hundred F_2 plants were obtained from two barley crosses. From these about 200 F_3 families were grown, and

elimination was begun on a basis of straw-length, time of ripening, and other characters as judged by eye. By the F_7 generation ten segregate families remained. They appeared homozygous in all characters, and to have specific merits. Because of the great number of segregates handled in previous years there was insufficient seed on hand of the ten remaining families to put down field-scale (*e g.*, ¼ to ½ acre) observation plots, but it was felt to be desirable to have as large plots as possible brought under observation without delay. The requirements of other breeding work made it impossible to arrange a chessboard test of the ten families. In any case, such a test upon ten varieties would be a very big undertaking.

Finally it was decided to grow the ten hybrids with two standard varieties in parallel beds, repeating every hybrid and both standards three times.

The standards will be referred to as A and B, the hybrid varieties as C to M (omitting I). One bed of each was sown in the order A to M, the arrangement being thrice repeated, and so making thirty-six plots in all. As later explained, systematic linear repetition of such a series of varieties is usually undesirable in yield trials where high statistical significance is sought. In this case it had the great merit of convenience. There are certain characteristics of which the relative degree in each of a number of varieties becomes apparent only after many weeks of observation. Straw features, the "neck," and the response to wind, are typical of this kind of characteristic. To be able to walk past the twelve varieties in the same order, thrice over in one passage along the plots, greatly assists the intuitive kind of observation such elusive characters call into play. A non-repeating order of varieties is always "inconvenient" for continual observation. The principle of "convenience for observation" can be put to the test only by experience. But in all plot work it repays deferential study. Again, as a matter of convenience, a path 18 inches wide was left between every bed and the next. Around the whole series of plots a path 4 feet wide was made. As later explained, paths and open borders should be avoided in precise formal trials. They leave the edges of a bed free from competition, and thus, in effect, with a greater spatial interval than that of the middle of the bed. But the paths, arranged as described, gave ready access to every plant on every bed, and observation, to be of value, must extend to the whole of the plant population concerned.

By harvest certain fairly definite conclusions were reached.



THE SUCCESSION OF PLOTS OF VARIETIES A–M THRICE REPEATED

FIG I.

Four of the ten hybrid varieties appeared to deserve further test. And such a number with two standards would be suitable for a chessboard trial plus large observation plots in the year following. Rabbits damaged one end of the series of plots in early spring, but otherwise everything went very well. It was decided to harvest and weigh the individual plots to see how the result stood in relation to conclusions based on observation. The plot yields of grain are shown in Fig. 1 (ordinates). In that figure the succession of letters A to M indicates the order in which the beds were arranged.

The low plot yields at the left of the series are partly attributable to rabbit damage, but aside from this there appears to be a steady improvement in yield from left to right all across. Remembering that the plots on the extreme left were damaged, we may now notice certain definite features or trends in the diagram. Varieties A and G are regularly below average in yield; varieties L and D are regularly above average. The remaining varieties are either about as good as or better than the better standard—viz., B. It will be seen that the A to M portion of the curve tends in all three replications to preserve the same general form. In other words, the varieties maintain (at any rate in the second and third repetitions) more or less the same relative positions of merit. Such a trend-constancy in results, apart from any measure of significance, constitutes admissible general evidence. These facts agreed well with the conclusions suggested by observation. Final selection was as follows:

A and B—standards.

C and D—were in general similar, but D appeared to have given a better yield and to have a slight superiority in quality. C was rejected, and D kept for further trial.

E—was mediocre for yield, had a rather weak-necked straw, and was not of outstanding quality; rejected.

F and G—were in general similar, but of a type distinct from the other hybrids; G was rejected for low yield—it had very small ears; F was kept because, though not outstanding in yield (it appeared not to tiller very well), it was distinct in type, and showed very fair quality.

H—mediocre yield; distinct tendency to lodging; rejected.

J to M—very similar in general appearance; K had weak-necked straw; M was of disappointing quality (noticed also in previous year); L was below J in quality; therefore J was kept for further trial and the rest rejected.

In this way four hybrids were selected for further test out of a total of ten. Circumstances made it imperative to rely on "observation," but plot weighings, made as a matter of interest, offered rough confirmation of the observational results. This case has been described simply to illustrate a small form of observation plot which has proved useful, and to call attention to the question of convenience in working.

§ VIII.—The Chessboard Yield Trial.

The underlying ideas of this method were first set forth in an appendix by "Student" to Hall and Mercer's paper, "The Experimental Error of Field Trials," published in the *Journal of Agricultural Science*, vol. iv., 1911. We commend both paper and appendix as classics of yield trial literature. The routine procedure and sowing implements were brought into use by Dr. E. S. Beaven of Warminster.

Among small-scale trials, the chessboard method, as used for cereals, is pre-eminent. But little seed is required, so that the method is well adapted to early stages of new hybrid varieties. With care and under good conditions the degree of reliability is such that, with wheat and barley, significance attaches to inter-varietal yield differences of 4 to 5 per cent. *for the weather of the given year*. It is not a great undertaking to "cage" the small area of the test with netting fine enough to keep out sparrows. A cage is essential, for the damage inevitable with small grain crops would completely upset uniformity of result. That a test of this kind occupies so small an area has solid statistical advantages. It permits a relatively uniform piece of land to be chosen. And the operations of sowing and harvest can be performed in a brief period —often in one day. Like every known and conceivable trial, it suffers from certain limitations to result. These were fully considered in § III. (*supra*).

The cardinal features of the method may be thus stated for cereals. Four to eight varieties may conveniently be included. There are about twenty plots, each 4 feet square, of every variety. These are so "scattered" that the combined plots of any one variety are thoroughly representative of the whole test area. Such representativeness is secured by the use of a considerable number of small plots disposed in a sort of "chessboard" fashion, as exemplified later. A constant number of seeds, at regular spacing, is sown on every plot. At harvest a 6-inch border is cut away from

every plot. This is to eliminate possible differential "competition" effects arising from the varied propinquity of varieties. After removal of the 6-inch border from the 4-foot square plot, there remains a square yard of plants. These square yards are separately harvested and weighed. The mean per-square-yard-yield of every variety is then determined. By the special methods fully explained in Section I., § 11, the standard error or measure of significance of the difference between two varietal means is also evaluated.

In illustration of the full procedure we may now consider a trial embracing two standard varieties (A and B) with five new varieties (C to G). We will suppose there are twenty plots of each variety—*i.e.*, 140 plots in all. A suitable arrangement of plots is shown in Fig. 2 (*a*). It is desirable to surround the actual plots-area (as shown in Fig. 2 [*a*]) by a border 2 to 3 feet wide sown, at the same spacing as the plots, with one of the standard varieties. Outside this border an 18-inch path for convenience of observation and work should be left if possible. Border and path are not essential, and in a small cage may have to be omitted. The merits and weakness of the kind of scatter of plots shown in Fig 2 (*a*) are separately discussed.

This account may give the impression that a chessboard trial is extremely arduous. That it calls for care and occasionally for hard work is beyond doubt, but sound planning and forethought make it a readily workable method. And, judged on results, no less than from the standpoint of theory, it is pre-eminent among small-scale cereal yield trials. It is hoped that those concerned with non-cereal crops, or who lack facilities for a chessboard trial, may find in the foregoing account some guidance as to fundamental principles. Moreover, it should be remembered that, so often in precise yield trials, failure comes from accumulated neglect of small matters.

Note I.—The plan of a chessboard plot is shown in Fig. 3. Its boundaries are the heavy lines PP, QQ, RR, SS, its size being 4 feet square. Eight lines of seeds are sown on it. These are marked I. to VIII. in the plan. Lines I. to VIII. are 3 inches away from the respective plot boundaries PP and QQ. Between every line and the next—*e.g.*, I. and II., etc., the distance is 6 inches. In every one of the eight lines 24 seeds are sown. Seed positions are marked on lines I. and II. and numbered on line I. as an illustration. Seed 1 is 1 inch from the boundary RR and seed 24 is 1 inch from the boundary SS. Between every seed and

the next—*e.g.*, 2 and 3, 3 and 4, etc.—the distance is 2 inches. The heavy broken lines TT, UU, VV, WW, demarcate the border, which is cut away at harvest. That is to say, all plants between these lines and the plot boundaries adjacent and parallel to them are removed. The distance between PP and TT, and so on, is 6 inches. Thus a square 3 feet × 3 feet remains for harvest. It will be perceived that 8 × 24 = 192 seeds are sown on every plot. The number of plants in the rejected border—assuming full survival—would be 24 in row I. plus 24 in row VIII, plus 6 (Nos. 1, 2, 3, and 22, 23, 24) in each of rows II. and VII. These total 84, and thus 192 − 84 = 108 plants per plot are harvested and weighed, less any losses in the square yard due to death of plants, etc.

Note II.—Plot arrangement is an important consideration. A width of five plots for seven varieties as in Fig. 2 (*a*) ensures a typical chessboard scatter. To emphasize the advantages of such a scatter of small plots in comparison with single plots, Fig. 2 (*b*) has been prepared, showing a simple linear arrangement of large single plots on exactly the same site. The shaded area in each figure represents the kind of "patch" so familiar in plot work; it may be low and wet, or a local wireworm attack, an unusually good piece of soil, etc. In (*a*) every variety is "in the patch," though not in precisely equal degree. In (*b*) the patch is almost confined to the plot of variety A. A similar consideration arises in connection with the edges in a case where no border is laid down. In (*a*) every variety tends to be located on an edge about an equal number of times, but in (*b*) the plots of A and G have three free edges to the two of the remaining varieties. This crude illustration has been employed to place emphasis upon the advantages accruing from many small plots suitably scattered. Only by repetition and appropriate scatter can high statistical significance be ensured.

Plot arrangements in a replicated layout open up a very difficult question. In calculating the necessary standard error for a chessboard comparison, plot deviations from varietal means are used in adjacent pairs. Now the way in which they are used is strictly valid only if they are "independent random samples." In view of the *systematic* repetition of varieties—viz., in alphabetical order—this condition is not necessarily fulfilled. How nearly or how little it is fulfilled we cannot tell, for we know virtually nothing of the disposition of soil variations. An escape from the difficulty lies in adopting a deliberately randomized arrangement. We might, for example, number the 140 plots in order, number

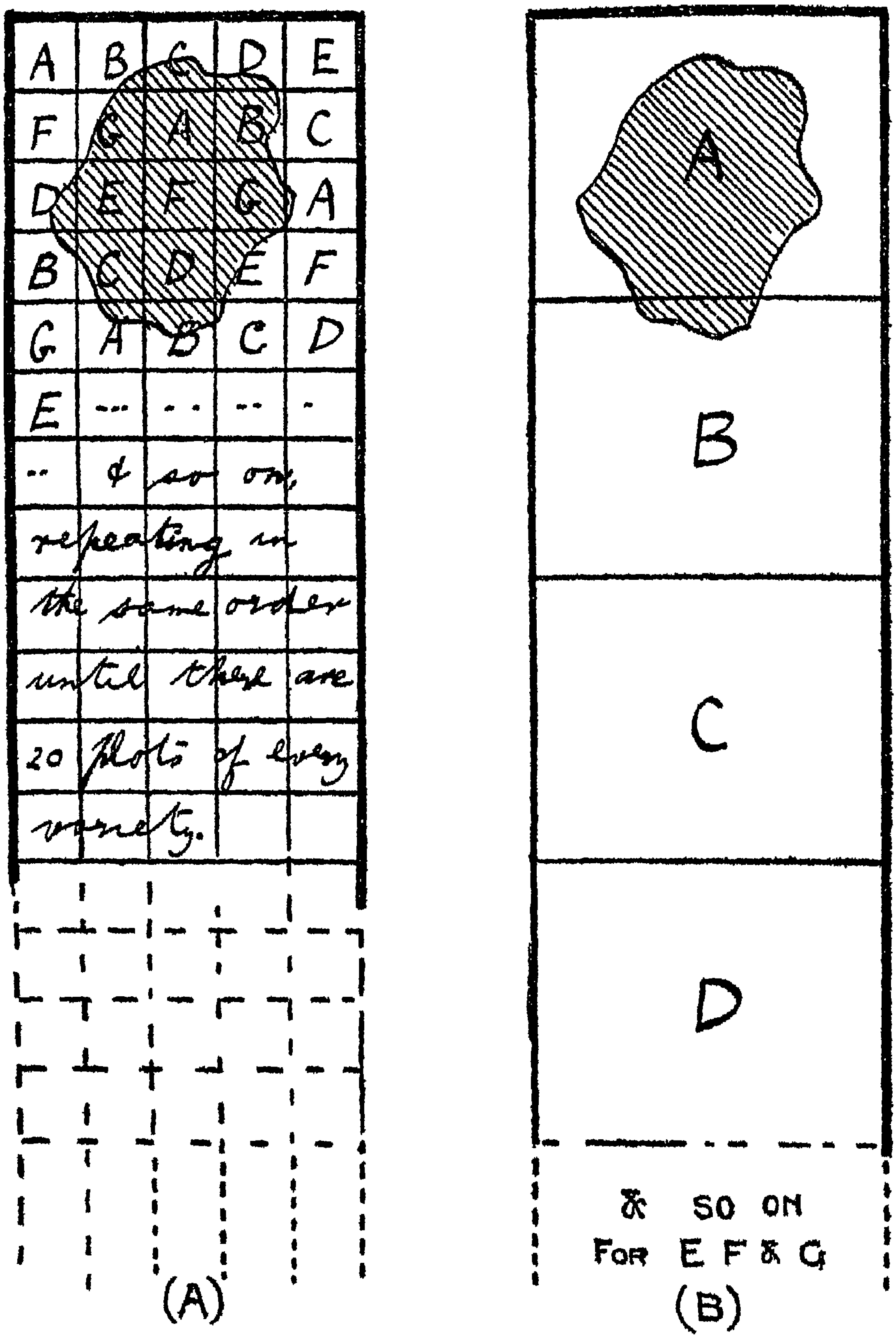
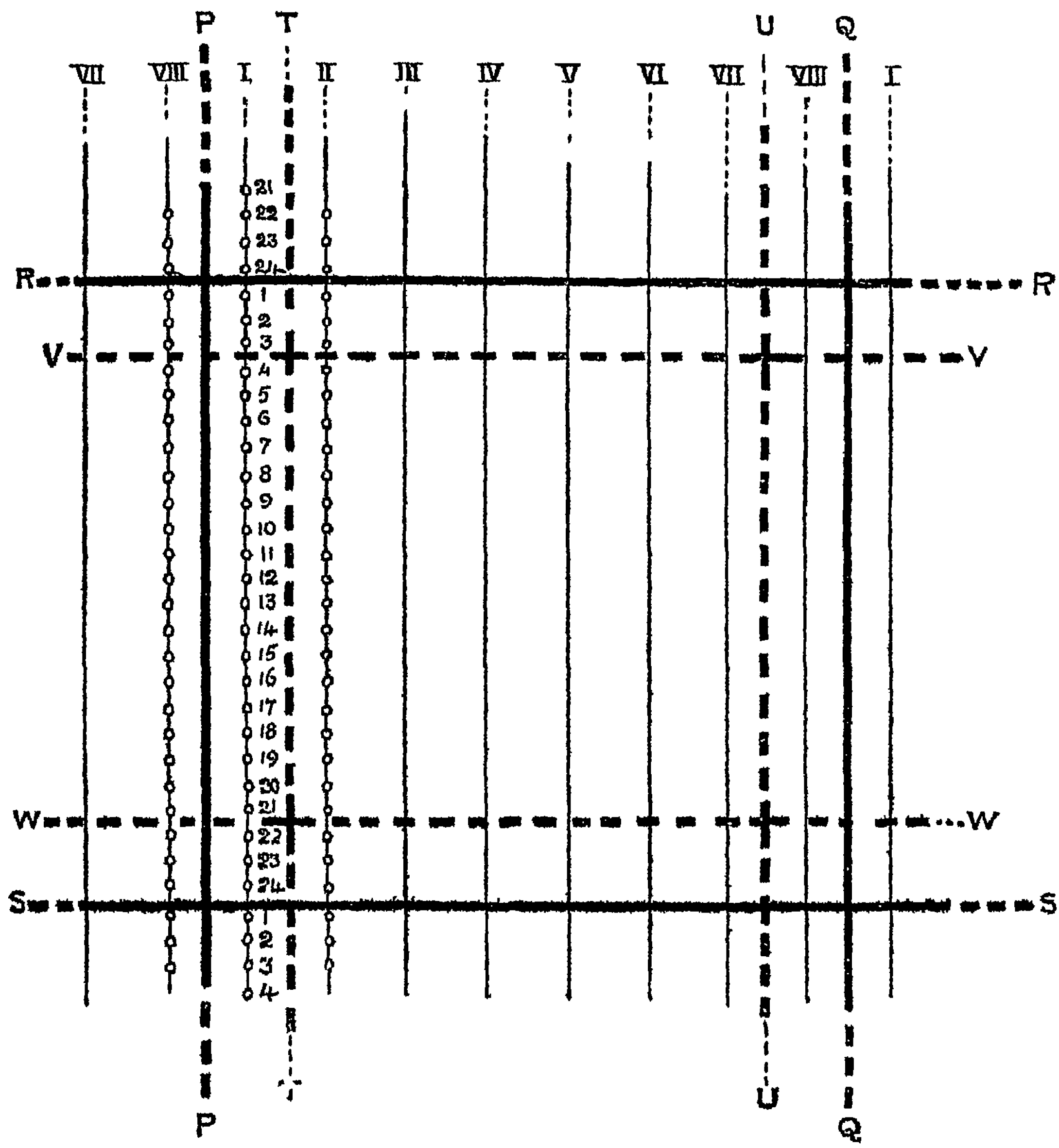

A B C D E
F G A B C
D E F G A
B C D E F
G A B C D
E
& so on, repeating in the same order until there are 20 plots of every variety.
(A)
A
B
C
D
& SO ON FOR E F & G
(B)

FIG 2


P
T
U
Q
VII
VIII
I
II
III
IV
V
VI
VII
VIII
I
21
22
23
24
1
2
3
4
5
6
7
8
9
10
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20
21
22
23
24
1
2
3
4
R
R
V
V
W
W
S
S
P
T
U
Q

FIG. 8.

140 tickets from 1 to 140 to correspond with them, and put these in one bowl; and in another, 140 tickets of which 20 are marked A, 20 marked B, and so on. Drawing one ticket from the first bowl we might draw, say, 73 and another from the second might give F. Variety F would then be sown on plot 73. Continuing the process every plot would be assigned a variety, and the allocation would be wholly random. We do not propose to follow these theoretical questions further for the reason that their importance appears to us nullified by practical considerations. The simplicity attaching to a repeating form of scatter—*e.g.*, Fig 2 (*a*), carries two solid advantages. It facilitates sowing, observation of the growing plots, and harvest. Anything which facilitates work in careful yield trials at such periods is of great value. Sowing randomized plots would call for constant reshuffling of the seed packets if the plots were, as is usual, sown one after another from beginning to end of the whole series. It might be avoided by sowing all the A plots wherever they might be, and so on, but for this the sower would have to tramp over his tilth again and again, and so poach it. A second advantage of simplicity is insurance against mistakes. In any considerable piece of plot work there is great risk of mistakes of the "damn fool" order An A label on a B sheaf may be more upsetting to results than the adoption, in the face of theoretical objection, of a systematically repeating pattern of plots.

When a chessboard trial has to be repeated a second year on precisely the same site—plot for plot, as must happen in a small cage—an interesting situation arises. It is easy to argue for and against the practice of allotting to every variety the plots it had in the previous year. How and why to avoid an exact replica in allocation of plots to varieties may be left as an exercise to those interested. If, as usually happens in careful trials, the varieties are close in inherent yielding capacity, little danger appears to threaten from an exact replica. The general question of plot size and arrangement is dealt with in § X.

Note III.—Counts of number of surviving plants and number of ears per plant in chessboard trials are valuable. The data for a trial of six barleys with twenty-five plots per variety may be used to illustrate this.

I., variety; II., average yield of grain per plot in grammes; III., average number of ears per plant; IV., average number of surviving plants per plot (out of possible 108):

I.	II.	III.	IV.
A	294	2·95	97·8
B	288	2·92	97·4
C	299	3·16	95·7
D	292	3·05	97·6
E	273	2·76	98·1
F	312	3·32	96·0

It will be seen that number of surviving plants is high and very fairly constant for all varieties. Thus differences in tillering are likely to be inherent and not mere reflections of survival rate of plants. Though small, the tillering differences (column III.) are of interest. In earlier years variety F has come to be regarded as the most prolific in ear production per plant. Its difference from A (standard) is fully significant. Similarly the low tillering of E accords with earlier observation. The expectation—on variety reputation and on observation in early growth stages—was that D would yield relatively much higher than column I. shows it to have done. Why this expectation was not realized was patent from an inspection of the threshed grain. Variety D has long ears with many spikelets per ear. Thus tillering being good (column II.), this variety must have produced a great average number of grains per plot, but it had, obviously, a high proportion of extremely thin grains. It is concluded, therefore, that the potentially high yield of variety D was checked by some circumstance inhibitory to grain-filling. A drought in June and July appears to have been this limiting circumstance. Curiously enough, this same chain of reasoning was also developed from independent considerations, which are now to be explained.

As Section I., § 11 makes clear, the special applicability of "Student's" method (for standard error of varietal-mean differences) turns on there being a correlation between adjacent plots. In this case the correlation must have been very low, for the standard error was about the same when computed by "Student's" method and in the ordinary way (actually, *vide* Section I., § 14, $\sigma_d = 36{\cdot}30$ and $\sqrt{2}\ \sigma_v = 38{\cdot}60$). As a matter of interest the correlation between adjacent plots was computed. Taking plots in pairs across—*i.e.*, every plot with the plot immediately on its right—the value was $r = +0{\cdot}116$. For plots in pairs downward it was $r = +0{\cdot}033$. These very low and non-significant values are somewhat exceptional, for in chessboard trials in general a fairly high significant positive correlation is found. There appeared to be three possible explanations for the low correlation. It might be supposed that the ground was quite exceptionally uniform. But,

having seen the subsoil from the post-holes when the cage was being built, one could be quite sure this was incorrect. Again, the ground might be supposed to be abnormally "patchy"—*i.e.*, so multifariously varying between close points as to show no definite trends at all. Experience does not support such an explanation. Finally, it might be supposed that the ground was such as to induce a fair correlation between adjacent plots; that up to a certain point in the history of the crop a correlation did exist; but that, subsequently, some limiting factor, such as the June-July drought, prevented the forward projection of the correlation, and also the full potential inter-varietal yield differences. As a test of this, correlations across and down were evaluated for number of ears per plot. This attribute was, of course, already determined by early June, when the plants emerged their ears and the florets became fertilized. The values found were:

$$r\text{ (across)} = +0{\cdot}327.$$
$$r\text{ (down)} = +0{\cdot}575.$$

Both these correlations are significant and decidedly higher than those for final yield of grain. They thus support the explanation given above.

§ IX.—The "Half-Drill-Strip" Method.

Field-scale trials remain for consideration. Their special merits, which small-scale trials necessarily lack, have been explained in earlier sections. On field scale any but a very limited repetition of plots is apt to be costly. Moreover, it may involve so considerable an area that major soil inequalities are encountered. Anything resembling a chessboard "scatter" of plots is impossible when sowing and harvesting are done with drill and binder. Consequently a series of long, narrow strips is the inevitable form of field-scale trials.

Suppose it were decided to compare varieties A, B, C, D by means of parallel plots and with every variety, say, five times repeated. A possible arrangement would be:

A B C D A B C . . ., and so on.

Soil variation is inevitable, and it may be supposed for argument that there is a steady decline in fertility from left to right. It would be unfair in such a case to compare every D with the A of its own series; for every D would be on an area of lower

fertility than the corresponding A. A more reasonable procedure might be to compare every D with, say, the mean of its own A and of the A in the next series. This would be purely arbitrary. And remembering that, as a fact, trends of soil fertility and character are never precise or regular, we perceive that even the second procedure would entirely lack the merits of a chessboard comparison.

Dr. E. S. Beaven of Warminster has devised the "Half-Drill-Strip" method, which very ingeniously overcomes the kind of difficulty we have considered. His account of it is in the *Journal of the Ministry of Agriculture*, vol. xxix., Nos. 4 and 5, July and August, 1922.* We commend it to all concerned with field-scale trials. It gives, beside the full detail of a method, a trenchant account of the general question of testing cereal varieties. With care, as he shows, inter-varietal yield differences of 3 per cent (*for the weather of the particular year*) can be significantly demonstrated from plots totalling only half an acre for each variety. We propose to set forth simply the fundamental principles of the method.

Every variety under trial is separately compared with the standard variety. For any one such comparison of variety (V) and standard (S) strips are drilled thus:

S VV SS VV SS, and so on.

A "strip" is half the width of an ordinary seed drill, and each S and each V written above denotes one such strip.

Now, assuming the yield of grain from every strip to have been found, the standard error of the difference between the mean yields of S and V (from all strips combined) could be determined in two ways:

(*a*) By finding the standard error of the mean of S and of the mean of V, and then by the usual formula, the standard error of the difference of these mean yields.

(*b*) By writing down the difference between the yields from adjacent strips in pairs—viz., S and V, then (next) V and (next) S, then S and V, and so on in order as the strips are written above. Then the standard error of the mean of these differences might be determined.

It will be perceived that (*b*) is in principle the "Student" method. A steady decline in fertility, such as was shown above to

* Reprints are obtainable gratis from the Secretary, National Institute of Agricultural Botany, Huntingdon Road, Cambridge.

weigh against the simple A B C D repetition, is completely allowed for by this form of comparison. Beaven cites one of his own trials in which the probable error (0·6745 standard error) of the difference between varietal means was :

For calculation (*a*)	... ...	1 41 per cent.
For calculation (*b*)	.. ...	0 55 ,,

Method (*b*) is, naturally, always used. It is of the essence of this form of trial that comparison of adjoining plots is made possible.

When a number of varieties is under comparison, the separate V with S sets of strips are laid down in a succession. Ingenious arrangements are made for sowing and harvest. The seed-box of the drill is halved by a partition, S seed being put in one half, and V in the other. Thus the drill can be led up, turned, led back, and so on without hitch. There are necessary precautions, such as rejecting end strips and squaring off the ends of all strips. A few extra precautions, introduced by Dr. Beaven since the publication of his paper, are described in the *Journal of the National Institute of Agricultural Botany*, No. 4, 1925, pp. 24-26.

It will be evident that the number of possible comparisons could be increased if every strip were divided, at harvest, into a series of equal plots. Adjoining plot yields could then be compared.

Those who contemplate employing this method must naturally master the full detail as set out in the original paper. Cost in money and time may place the method beyond many who are called upon to make varietal comparisons, but in connection with both cereals and other crops the fundamental principles will repay careful study.

One great practical merit of the strip method is the excellent opportunity it affords for "observation" of test variety and standard in large adjoining strips. This is a matter of great importance.

§ X.—Size and Arrangement of Plots.

The beginner, once convinced of the statistical inutility of single plots, is naturally anxious for some suitable pattern of replication. Two "regulation" patterns of proved value have been given in §§ VIII. and IX. It is proposed to give no others here, but to discuss cardinal principles. For the essence of success in yield trials is that the man on the spot, with full knowledge of

his circumstances and requirements, should devise his own pattern. Working facilities, the desirable degree of statistical reliability, and the special features of the crop and country concerned, must rank among the first considerations. Sufficient emphasis has been laid on these matters in the earlier sections.

Experience with cereal crops suggests that two main forms of trial are necessary and sufficient. For preliminary work, especially in the early stages of breeding, small-scale trials are desirable. Of these the chessboard method is the model. Before attempting to extend new varieties into cultivation field-scale trials are desirable. With cereals the strip test has proved extremely satisfactory for this purpose.

It appears to us probable that these two methods of trial will prove to have a wide suitability among crops in general. Specific modifications of plot size and procedure will naturally be called for. These will have to be determined by experience. For crops like cotton the numerous replications and very small plots of the chessboard, as described in § VIII., are naturally impossible. Larger plots must be employed, and our next concern is the size and arrangement most suitable for them. It is quite possible to devise a sort of intermediate scale trial. For example, we might have $\frac{1}{80}$-acre plots replicated to a limited extent and on a chess-board-like scatter. For crops sown and handled more or less as cereals are, they would be extremely inconvenient. If the seed were dibbed, only a very limited number of plots could be sown in one day. Thus but few replications would be possible. Sowing with an ordinary seed drill would be impracticable. The horses, turning at the end of one plot, would heavily tread the end of that next adjoining. And in sowing first all the plots of one variety, then those of another, etc., the drill would have to be led about interminably. Hand drills are to be obtained, but they have never given satisfaction in plot work. With drills in their present crude state it is almost impossible to ensure a uniform specified seed rate on small plots. Long parallel strips allow a good straight run for the drill. With cereals, from every point of view, such strips represent the most practicable plot arrangement.

For cotton, sown by hand-placing of the seeds on one side of the plough furrow, the intermediate scale scattered plots we have been considering could easily be laid down, but for general observation, for counts of flowering or boll-shedding, and for periodic picking, scattered plots would be very troublesome. Accordingly, we venture to suggest that the parallel strip method, following the

correct layout bears its full fruit in plot work undertaken for physiological studies. There precision is the sole objective. In yield trials other matters are of at least equal importance.

In devising plot arrangements theoretical requirements will again and again be found in conflict with working suitability. Neither can be ignored. To listen to the voices of both means compromise, and every successful arrangement is a carefully framed compromise. But even trials of the highest statistical significance have sharp limits in agricultural application; weather variability makes sport of the very small standard errors rigorously planned trials can be made to give; and mistakes or bad husbandry can undo the best theoretical exertions. We are thus inclined to urge that if any favour is shown in compromising, working suitability should be the recipient

§ XI—"Corrections" for Soil Inequalities.

It would be a considerable task to accord even brief notice to the many published writings on yield trials. Space limitations make it an impossible task. In any case there would be little reason outside of scholarly comprehensiveness for attempting it. The fundamental difficulties and fundamental principles are relatively few; the possible refinements and variations of method are almost innumerable. Practical experience can alone drive home the important lessons, and is to be commended before the most abstruse implications of theory. To many agriculturists mathematical conceptions have no homely savour. And there is some danger that over-intensity in the quest of high statistical significance may lead to neglect of agricultural significance. We accordingly content ourselves with giving a few references to the subject from which this section takes its title. In essence, such "corrections" are endeavours to ascertain, by mathematical treatment of the ordinarily observed plot-yields, some estimate of the relative "productive power" of the soil of every plot. The observed varietal yields are then accordingly corrected. Papers which well illustrate the principles and by bibliographies afford a key to the subject are: Surface, F. M., and Pearl, R.: "A Method of Correcting for Soil Heterogeneity in Variety Tests (*Journal of Agricultural Research*, vol. v., No. 22, 1916); Harris, J. A.: "Practical Universality of Field Heterogeneity as a Factor in Influencing Plot Yields" (*Journal of Agricultural Research*, vol. xix., No. 7, 1920).

"Corrected" figures are not real figures; they are abstractions. We feel that, in principle, they are undesirable. And what has been achieved with trials such as the chessboard and half-drill strip shows that they are unnecessary. They have sprung from a natural longing to attain statistical reliability at less expense—fewer and smaller plots. But from the agricultural side the hopelessness of appreciating "varietal remunerativeness" from very small-scale work is most patent, and it must never be forgotten that the discovery of varietal remunerativeness is the real goal in agriculture yield trials.

We have intentionally omitted all reference to certain mathematical papers bearing on the question of small samples, and giving modified formulæ and tables for use in the case when the number of observations n is very small—say, under ten*. The ordinary formulæ and methods then tend to give too low a value for P, the probability of a given difference arising solely as a fluctuation of sampling. But the use of special formulæ, as it seems to us, simply tends to give a false idea of security and precision, for in agricultural work with a very small sample (*e.g.*, of four or five observations) *the value of P, however obtained, is quite untrustworthy*, and this untrustworthiness is the important point. The ordinary man will do best to use the simple rule, *very small samples cannot be trusted*—and leave it at that.

The form and substance of this writing have been decided upon an experience of six generations of "cotton men," whom it has been our pleasure to try to assist. We hope they may find in it some help with certain aspects of the problem of increasing the output of Empire cotton upon which they are now engaged.†

* *Cf.* "Student," "The Probable Error of a Mean," *Biometrika*, vol. vi., p. 1.

† We have not given references to ordinary mathematical tables for facilitating calculation. Barlow's tables giving squares, cubes, square roots, cube roots, and reciprocals of all numbers from 1 to 10,000 (E. F. Spon, Ltd., London) are invaluable and inexpensive. For work in correlation where a calculating machine is not available, large multiplication tables are useful; the least expensive is Zimmermann's *Rechentafel*, giving products up to $100 \times 1{,}000$ (Wilhelm Ernst und Sohn, Berlin).

AN ACCOUNT OF A TOUR THROUGH THE EASTERN SECTION OF THE COTTON BELT OF AMERICA

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The present visit was undertaken primarily with a view to studying at first hand some of the pests to which the cotton plant is subject, and at the same time to gaining some knowledge of current problems of research in cotton cultivation generally. About two weeks were spent in the Cotton Belt, first at the North Carolina Agricultural Experiment Station at Raleigh, then at the South Carolina Branch Experiment Station at Florence, and lastly at the Delta and Pine Lands Plantation of the Fine Spinners' Association at Scott, Mississippi. Most of the time was spent at the two former, where full facilities were afforded by Drs. Winters and Lehmann at Raleigh and by Dr. Armstrong at Florence. I am also indebted to Mr. L. O. Watson of the Watson Seed Company at Florence for much help in connection with the wilt disease problem.

At the date of arrival at Raleigh (August 18) the cotton crops were still green and flowering freely, and no open bolls were to be seen. In the neighbourhood of Florence the crop was much more advanced, and picking was proceeding on the earlier and drier fields. By the time the Delta region was reached, picking was in full swing, so that altogether an opportunity was afforded of seeing the crop in a considerable variety of stages.

In Dr. Winters' department at Raleigh considerable attention is paid to the teaching of the general principles of cotton cultivation, and in this connection a representative collection of cotton varieties is maintained in the experimental grounds for demonstration purposes. These comprised about a dozen varieties of Upland type, one of Sea Island, and one of Pima (Egyptian type). The Sea Island plants at Raleigh were the only ones of that type seen in the United States, as the industry has almost, if not quite, died out there of recent years as a result of the ravages of the boll weevil. This is due to the Sea Island type being a more slowly maturing plant, and in particular

to the fact that the bolls of Sea Island cotton harden more slowly than do those of Upland types, and so are exposed for a longer time to the risk of puncturing by the weevil.

The two varieties most in favour in North Carolina are the Mexican Big Boll and the Cleveland, the former with a $1\frac{1}{16}$-inch, the latter with a $\frac{7}{8}$-inch staple. From the grower's point of view the two varieties are of about equal merit, the Cleveland variety more or less compensating for its shorter staple by a somewhat higher yield. The field crops in the neighbourhood were not tall, as they had been held back by a drought earlier in the season, but the general anticipation was that a good crop would be realized. In some of the fields visited the crop was estimated at three-quarters of a bale per acre, which is distinctly above the average yield for the whole cotton belt (rather less than three-fifths of a bale per acre).

An experiment in cotton breeding is being carried out at this station under the direction of Dr. Winters, and has reference to the inheritance of "fuzz" on the seeds. Strains of the "King" variety are used for this purpose, and according to the work done here nakedness in seeds is dominant to fuzziness. As this result has been called in question by another worker, the selfed F_2 generation is being grown in order to obtain further evidence. The quality of nakedness in seeds has of late years come more into favour than formerly as the absence of fuzz favours speedier germination, a matter of importance under boll weevil conditions. Naked seeds have the further advantage of being easier to sow and easier to disinfect for the control of seed-borne diseases. Hitherto they have been objected to from the general idea that fuzzless strains are inferior in other respects.

It has been shown that more or less all degrees of fuzziness can be obtained simply by selection within a variety, so that there is no need to carry out any particular crossing scheme in order to gain this result. This, it was gathered, is the general attitude throughout the cotton belt in the matter of breeding for any purpose—viz., that an almost endless series already exists, so that most commercial needs can be satisfied simply by a continued process of selection. The present requirements are not so much for new types as for purification of those already in use, with an ultimate gain in productiveness and uniformity. The general objection raised to crossing is that it requires as a rule seven years longer in order to stabilize the chosen strain than is found to be the case with the process of straight selection.

As regards the work being carried out at the North Carolina Station on cotton cultivation, more attention seems to be directed at present to the other crops which are included in the rotation than to

the cotton plant itself. The soils of the eastern cotton states, and more particularly those of the coastal plain areas, are of a very light nature, lacking in humus and hungry as regards manure. The question of leguminous intercrops as soil builders is therefore well in the foreground, and a good deal of attention is being paid to the culture of various legumes at the North Carolina Station. The crop which is receiving most attention in this direction is the soy-bean, which appears to be coming into favour in place of the cowpea. The reason for this is its greater utility as a forage crop. In the college fields a large number of varieties are on view. They show a remarkable degree of variation in habit, some being erect and stocky, others scrambling, some tall, others dwarf, and so on. A considerable amount of actual crossing and selection has been, and is being, carried out at present with a view to raising improved varieties.

Except for a very few varieties which are resistant, neither soy-bean nor cowpea can be safely used to intercrop with cotton on land which is infested with the wilt or the root-knot organisms. In such a case the custom has been to plant one or other of the resistant varieties of cowpea, but of late the varieties of velvet bean, which is immune, have come into favour, and these likewise are receiving attention from the point of view of improvement.

With regard to the prevalence of diseases, the season had been on the whole rather dry, and thus some of the diseases which are favoured by wet weather were rather difficult to find. However, examples of all the diseases which are of any consequence in the eastern states were seen, either at Raleigh or at Florence. At Raleigh the only one which was at all common was the bacterial disease, chiefly in the form of angular spots on the leaves, though here and there the first symptoms of boll attack were seen. The black-arm stage of this disease was not observed; in this form it is not at all so common on Upland as on Egyptian and Sea Island types, and it does not appear to be a matter of great consequence except, perhaps, in abnormally wet years.

The experiment station at Florence, S.C., which is a sub-station of the South Carolina Agricultural College, is mainly concerned with the study of the boll weevil problem. A period of three days spent there was very instructive of the change in methods and in objectives which the coming of the boll weevil has enforced in cotton cultivation in America. Old varieties have had to be abandoned (of which the Sea Island types are one illustration), new ideals have arisen in breeding and selecting, and methods of cultivation have undergone change.

The essence of the position under boll weevil conditions is that the

later maturing part of the crop is practically wiped out. Wet years and wet situations favour the weevil, and therefore all tendencies to rank growth, overcrowding, horizontal and low branching, etc., favour the attack. The aims kept in view are now somewhat as follows: to develop by selection or, if necessary, by crossing, early maturing strains in so far as this can be effected without loss of lint length; to select varieties which develop a maximum of bolls in the early part of the season, and which have rapidly growing and hardening bolls; to reduce to a minimum shedding of the early formed bolls by cultural methods which render the plants less sensitive to spells of drought (this means the keeping up of the humus content of the soil); to encourage a more upright type of growth, and to reduce the number of lower spreading branches, and generally to aim at having more plants to the row and each plant smaller than formerly. This new type of plant is developed partly by selection, and partly by late thinning, whereby the lower branches tend to be inhibited. Over and above these palliative measures of a cultural nature is the campaign to reduce the amount of attack by direct measures against the weevil.

The research programme at the Florence Station is of a very elaborate character, involving botanical, entomological, and agricultural investigations. A comparative study is being made of the rates of flower bud and boll development, together with determinations of the minimum size and age of flower bud ("square") which is capable of hatching out a weevil, and of the maximum age of boll which can be penetrated by the egg-laying female. The flower buds are attacked at any age and are shed, but it is only when the bud has reached a certain size that it is capable, even under favourable weather conditions, of hatching out a weevil. With regard to the penetration of the bolls, the interesting point has been noticed that it is the inner layer of the capsular wall which finally prevents the egg from reaching the interior of the boll. Many cases were seen where the boll had been pierced on the outside, but the egg had lodged in the hard inner wall of the carpel and produced there a small innocuous gall. There are considerable differences among varieties in the rates of hardening of this inner layer (Sea Island varieties in particular being very slow in this respect), and the degree of escape from boll weevil varies accordingly.

The fact that the weevils developing in the shed squares or bolls are destroyed if exposed to strong drying in direct sunlight opens up certain avenues of attack. Cultural methods are directed towards intensifying exposure to sunlight of the soil between the rows, hence the movement towards smaller plants with a more upright and less

branched habit. For the same reason it is advocated that the ground between the rows should be cultivated into a kind of groove so that the shed squares will tend to gravitate into the middle, where they will be more exposed to insolation. Similarly, the rows should run north and south, so as to allow the midday sun to get freely at the ground between them.

Experiments are also being carried out to see whether it is practicable to destroy the oncoming broods of weevils by harrowing them under. This method appears risky, as it more or less insures that the weevils will be kept from drying up, so that any success along these lines will depend on how far the weevil is capable of working its way up through the soil.

A very detailed bionomical study is being made of the insect itself: the date of its emergence from hibernation; the percentage of survival over winter in different substrata such as pinewood humus, corn stalks (the percentage of survival is actually very small); the flying and migrating habits; the number of bolls which a single female can parasitize, etc.

The so called "Florida" method of weevil control has been carefully tested out at this station, and has been found to give definite results, not only from the point of view of increased yield, but of increased profit as well. In both these particulars, however, it has proved inferior to the calcium arsenate method of dusting. The "Florida" method consists in the removal of all the squares from the plants at about the time when all the weevils have emerged from hibernation (say the third week of June). The underlying idea is, of course, to destroy the first brood of the insects, and thereby to reduce effectively the number present at the time of maximum flowering of the crop. The results obtained show a very effective control up to about the end of July—in fact, up to this point, a degree of control decidedly better than is obtained by calcium arsenate dusting. But from about the beginning of August the plots treated by the "Florida" method tend to approximate to the conditions of the untreated plots, and thus in the aggregate to fall much behind the plots which have received the calcium arsenate dusting. Under American conditions of labour costs, the single stripping of the squares costs fully three times as much as a single application of calcium arsenate dust.

The testing of various insecticides, with a view to determining the most effective preparations and the best methods and times of application, constitutes, perhaps, the major portion of the work of the Florence Station. Various proprietary articles have been tested and

found to be inferior. Calcium arsenate in one form or another has proved the most effective insecticidal agent, and every effort is being made to perfect the technique of applying this poison. Two main methods of application have been on trial, one in the form of a suspension in sugary water which is put on either by a mop or by spraying, the other in the form of a dust. The dusting method has so far given the greater measure of success. One striking result obtained is that applications of the poison in any form are remarkably ineffective early in the season. No advantage, it appears, is gained by dusting or spraying during the pre-square stage of growth.

The number of weevils that can be found on a plant is no indication of the number actually present, as they hide very effectively in the daytime. Even in a badly infested field it often requires some time and patience to find one. Thus it is not practicable to measure the state of infestation of the various experimental plots by counting the number of weevils present. The method adopted is to begin the treatment in each case on plots which already show 10 per cent. infestation of the squares. Dusting is done, whenever possible, while dew is on the cotton plants and while the air is as calm as possible. A considerable number of applications (up to 10) may be given at about four to five-day intervals.

The general impression conveyed by the work of this station is that it is being very well done. Nothing is being left to chance, and the whole ground is being systematically explored. Much of the work is, of course, of a semi-routine character, involving endless counts of squares and bolls, punctured or otherwise. Needless to say, the carrying out of an investigation on this scale requires a very considerable staff of field recorders.

A noteworthy feature of the boll weevil has already been alluded to—viz., that they are difficult to find even where they may be abundant. Furthermore, the external damage to the bolls is insignificant. A damaged boll shows nothing on the outside beyond a pin-head-sized rough swelling (the point where puncturing took place), which, in fact, is more easily found by feeling with the fingers than by seeing. With this negligible amount of outside damage, the whole contents of the boll may be and usually are ruined. The presence of the boll weevil thus introduces considerable possibilities of error into crop forecasting—that is, so long as the bolls are immature. When the bolls open, the damage due to the weevil attack becomes sufficiently obvious.

There are, however, two ways in which the amount of boll weevil infestation may be roughly judged. On the one hand, a field which is flowering freely is one which is comparatively free of infestation;

on the other hand, a field which shows marked unevenness in size of plant is one which is probably already infested. The taller plants, on examination, will prove to be badly parasitized. They have shed most of their bolls, and in accordance with the well-known rule they continue to put up new growth in the effort to make good the loss.

The angular leaf-spot disease was met with here quite frequently, but not producing appreciable damage. The same applies to an *Alternaria* disease of the leaves, but apparently it was only the older and more or less moribund leaves that were attacked, so that there was probably no real damage. A certain amount of anthracnose on the bolls was also met with, but the season had been too dry for any noteworthy outbreak of this disease. Anthracnose is said to be becoming commoner in the cotton belt than formerly, and in the aggregate the damage effected is considerable, but apart from occasional years and particular localities, it does not receive much attention. A few patches of wilt were seen on the station grounds, but better illustrations of this were met with later in the same district.

Two days were spent with Mr. L. O. Watson, the breeder of one of the best-known wilt-resistant varieties. The "Dixie" variety was originally obtained by selection on wilt-infested land, but proved to be too late in maturing under weevil conditions. It was therefore crossed in 1910 with an early variety—"Triumph"—and the present "Dixie Triumph" is a selection from the cross. It was not until about 1919 that the strain was fixed. After a further four years it had been multiplied up to a field scale. (The rate of multiplication of cotton seed on a large scale is given as about fifteen, though this figure can be much exceeded in small plots.) Visits were paid to the plots where the original selections are being made, the seed from each selected plant being grown in the following year in a row by itself, and only the most promising rows being selected. The best rows are then grown on plot scale, and in the following year on field scale. This process of continuous selection is being kept up from year to year, and in every case on land which is known to be infested with wilt to such a degree that the ordinary varieties cannot be grown successfully. It is only by this means that the wilt-resistant quality can be guaranteed, as any susceptible plants are automatically selected out by the fungus itself. Any plants showing a trace of wilt are carefully rogued out. They are easily detected from the appearance of the leaves, and the presence of a black stain in the vascular strands affords conclusive proof.

Visits were paid to two farms in the neighbourhood, on each of which about 100 acres of "Dixie Triumph" were being grown for

seed purposes. The soil of both farms was well infected with wilt, and it was very striking to see a heavy crop of the resistant variety in a particular field where the cotton crop had been a complete failure in the preceding year through wilt attack.

In the course of this trip a good deal of wilt was seen as the soil thereabouts was generally of a light, sandy texture and therefore more susceptible to wilt. "Rust," associated with scarcity of potash, is also a feature of such land, and a considerable amount of this was seen.

In the neighbourhood of the selection plots, the "root-knot" (Heterodera) disease was found abundantly on okra (a malvaceous vegetable) and tomato. It was not seen on cotton, though the latter is susceptible. Root-knot itself does not severely damage cotton, the galls formed being quite small, but it is dangerous inasmuch as it predisposes to wilt, and in the presence of root-knot the immunity of wilt-resistant varieties tends to break down. When both the wilt and the root-knot diseases are present, the latter must first be eliminated before wilt-resistant varieties are planted. This is effected by a three years' rotation in which only crops immune to root-knot are planted. Such are the cereals and various legumes—viz., velvet beans, peanuts, and the resistant varieties of cowpea and soy bean.

The visit to the Delta and Pine Lands Plantation unfortunately lost most of its interest through the absence on holiday of Professor Ewing, the breeding expert. This plantation of about 50,000 acres is devoted almost exclusively to cotton. Between cotton crops the land is simply left fallow. The method of working this large plantation is interesting. The estate is let out to farmers on a profit-sharing system, and these again sublet to negro families, also on a profit-sharing system. The farmer supplies mules, implements, capital, etc., while the negro families supply the labour.

The whole area is planted out with two quite recent varieties of long-staple Upland, the one having a slightly longer staple, but being a somewhat lighter cropper than the other. The breeding and selection plots from which these varieties were derived were seen, but full explanation was not available in the absence of Professor Ewing.

The visit to the Delta and Pine Lands Plantation marked the finish of this trip as far as the Cotton Belt was concerned. Originally it had been intended to visit a number of other stations in the southern states, but limitation of time finally prevented this. The detailed programme of the tour was prepared at Washington with the assistance of Dr. Gilbert and Mr. Cook of the Bureau of Plant Industry, and it is with great pleasure that I record here my thanks to both these gentlemen for their invaluable help in this connection.

FIFTH ENTOMOLOGICAL PROGRESS REPORT (AUSTRALIA), SEASON 1925-1926

RECEIVED FROM

E. BALLARD,

Cotton Entomologist appointed by the Corporation, attached to the Commonwealth Government of Australia.

THE present cotton season was characterized by early rains followed by a very long period of dry weather. Those farmers who had had their land prepared early secured a good strike, but generally speaking, sowing was late, and took place in November and December. In many ways conditions were similar to those of 1923-24, and have been attended by the same results.

The early-sown crops were mostly affected to a greater or less degree by cut-worms (*Euxoa radians*). These caterpillars eat the leaves of the seedlings, and in some cases cut the stems. A certain number of farmers lost the whole of the first sowing and were forced to replant. The attack was general by the time I returned from New Guinea, and I immediately notified through as many newspapers as possible the remedies to be used.

On the Research Station at Biloela and at the Agricultural College at Gatton, and also on my observation plot at Government House, Brisbane, we were able to check the attack at the outset. The usual cut-worm bait was applied with complete success. At Biloela the outbreak was immediately checked by paradichlorbenzene, a crystalline substance used in North Queensland for checking the ravages of the cockchafer grubs attacking sugar cane. Its use was first brought into practice in the United States. When in contact with the soil a poisonous gas (toxic only to insects) is evolved which remains in the soil for a considerable period. The drawback to its use is that it is very expensive (1s. 3d. lb. in bulk). It was not, therefore, recommended to the farmer, who was advised to use an arsenic-poisoned bait. Attacks by cut-worms usually take the farmer by surprise, and by the time he has ordered the necessary insecticide the damage is done and the crop lost. Bearing this in mind, I have endeavoured to get some of the Local Producers' Associations to keep a stock of calcium arsenate dust (the insecticide most likely to be

required by the farmer) which they can sell to those requiring it at cost price. I am awaiting the result of my suggestions. Three or four secretaries have promised to put the matter before their members.

It was stated above that the dry spring of this season resembled that of 1923-24. One of these resemblances is the damage that is being done in certain areas by the maize grub (*Heliothis obsoleta*), which over nearly the whole cotton belt in 1924-25 did very little damage, but which was very severe in 1923-24. I anticipated such an attack this season, and published the results of our work with a maize trap crop, and asked for the co-operation of the farmers for this season. Very few, however, responded to the suggestion, but at Biloela the whole of the farm crop, with the exception of one plot, was protected in this way. It is as well that this had been done, for in the vicinity of the farm and on the farm itself the maize grub population is very high—as bad as anything I have seen before. As a result of this even the trap crop did not attract all the moths, and there was some overflow on to the cotton, more especially the late-sown cotton. In spite of this the " bottom crop " of first formed bolls was saved, and it is the destruction of these that proves so great a loss as there is nothing to hold the plant down, and, especially on certain soils, the plant produces only vegetative growth, and does not set any squares.

This late-sown cotton was in its most attractive condition—*i.e.*, squaring—just as the maize grub population was approaching its maximum. Where trap crop maize had been planted the great majority of moths laid on this instead of on the cotton, and thus the first formed squares were saved. Laying was still in progress on the second sowing of maize at the time of my visit to Biloela, and though some eggs were being laid on the cotton the great majority were on the month-old maize. Next to the Research Station is a selector who has some 30 acres of cotton sown late, the same time as the bulk of the station crop. About half of this area is away from our trap crop rows, and on this part, although there was at first promise of a fine crop of cotton, little or no bottom crop has been able to reach maturity, nearly all the first squares having been eaten by the maize grub. Though one's sympathies are with the farmer who had taken a lot of trouble with this, his first crop of cotton of his own, yet one could not help being gratified at the success of the trap crop in protecting our own cotton in the face of such a heavy attack. This selector's land, where it came under the influence of our trap crop, which it did to a slight extent, showed a very much greater number of maturing bolls, even though the

protection was only partial. We are having this farmer's crop dusted with calcium arsenate both as a demonstration of its use and as a protection for the station crops. In this connection I might say that it is desirable to purchase for the station a horse-driven dusting machine which could, where necessary, dust crops for farmers on contract. I think that a communally-owned dusting machine of this kind would be very useful in districts where farms are situated close to one another, as they are in the Upper Burnett and Callide settlements and in other parts of Queensland.

One plot of cotton (about 3 acres) on the farm which was not protected by a trap crop had to be dusted once. This crop was sown early, and the usual rotation maize near-by afforded sufficient protection for it early in the season so that a good crop of bolls has already ripened. The succeeding squares were, however, infected, but one application of 5 lbs. per acre was sufficient to check the grubs. It is my intention to try this dust diluted with lime so as to bring the cost more within reach of the farmer; 1s. 4d. a pound or 7s. to 10s. an acre is, I consider, rather too high a price to pay exclusive of the cost of labour.

To return to the subject of the trap crop. The problem naturally arose as to how to dispose of the crop when it was cut, as it must be cut green and not allowed to mature. This part of the whole question has, I think, been settled by the co-operation of the Cotton Section and the farm manager at Biloela. As each successive planting of maize is cut, it is being put into a stack silo. The cutting is done by means of a slide or sledge to which is attached a scythe blade. By using a stack silo the farmer gets a reserve of fodder for his dairy herd (cotton-growing being usually an adjunct to dairying), and he also acquires the habit of fodder conservation. This helps to pay for the time spent in planting and cutting the trap crop. At the end of the season I hope to be able to publish the full cost, including labour, of this method of cotton crop protection, so that it can be compared with the cost of dusting.

I shall also be able to tell whether the maize crop is sufficient to trap the Peach Moth (*Conogethes punctiferalis*). Normally, as has been stated in former reports, the Peach Moth does not attack the cotton until the maize second sowing is drying off. With the trap crop maize there is one sowing a month later than the normal last sowing done by maize growers. Thus growing maize will be available for the moths to lay in when in normal circumstances they would attack the cotton owing to the absence of maize. In a season when the cotton crop ripens early, as happened last year (1924-25), Peach

Moth damage is very slight, or even absent. With so much late-planted cotton I expect Peach Moth damage to be heavy in the present season. An early ripening crop gets a large proportion of its bolls set before either maize grub or peach grub is in sufficient numbers to do any serious harm; a late crop is most vulnerable at the period when these two pests are at or near their maximum concentration. Both, so far as one can tell from three seasons' observations, are dependent on the maize crop. Where only cotton is grown and there is no maize, Peach Moth grubs attack the cotton early in the season, as has occurred in some parts of Queensland this year.

The Entomological Section is very short-handed, and has been unable to supply me with an assistant this season; moreover, the field staff of the Cotton Section is not so large as last year, as there were not sufficient funds for the graders (who before the ginning began assisted the field staff) for travelling. In consequence, I have not been able to keep in touch with all parts of the cotton belt.

In Brisbane I have been studying the maize grub with reference to its parasites, which this year seem very scarce, and the reactions of the grubs to soil temperatures and soil condition—*e.g.*, moist and dry soils, etc.—the idea being to see whether from certain conditions of temperature and rainfall one could forecast the likelihood or otherwise of a severe outbreak in any particular season. So far it would seem that very moist soil is inimical to development of the pupæ, and during continued rain accompanied by high atmospheric humidity a bacterial disease becomes very prevalent. Studies of this nature would have to be extended over several seasons before any final decisions could be reached, but they have an important bearing on the whole problem.

When the Stainer (*Dysdercus sidæ*) arrives in the fields I hope to be able to evolve some means of controlling it, as it is an insect of first importance. So far this season it is conspicuous by its absence, although it should have put in an appearance some time ago, as all the early-sown crops are in the stage when they are most attractive to it.

BRISBANE,
February 3, 1926.

COTTON-GROWING STATISTICS—VIII

COMPILED BY
JOHN A. TODD

IN the issue of April, 1925, we gave a table (No. VII.) showing the position of American cotton in the world's supplies. That table now requires revision for two reasons of special interest. In the first place, the American crop of 1925 carried still further the remarkable recovery which the 1924 crop had made from the very low levels of 1921-1923. The figures available are not yet quite final, but it is obvious that the crop will slightly exceed 16 million bales excluding linters, and the linters crop will certainly exceed a million bales. The result is that the total crop including linters is certain to establish a new record; in fact it may do so even excluding linters, for the 1914 crop in equivalent bales of 500 pounds gross reached the total of 16,134,930 bales, and the corresponding figure for the 1925 crop, though at present it is only 16,085,905 bales, may easily be added to in the final adjustment. It may be noted in passing that the increase of the linters crop is largely due to the increasing demand for linters as the raw material for artificial silk. The record linters crop was 1,330,714 bales of 500 pounds gross in 1916-17 when the demand for linters for munitions purposes was at its highest, and it is possible that even that figure may be equalled this year. This new demand is going to make a big difference in the value of linters, and therefore in the probable supply in future years, and will add considerably to the confusion already caused in American crop statistics by their inclusion or exclusion.

The second point of interest in the table is the much larger proportion of medium or Grade II. cotton now attributed to India. In the issue of July, 1924, we gave a table of the Indian crop by varieties, distinguishing between those mainly below ⅞ inch staple and those of ⅞ inch and above. The publication of that table attracted a good deal of attention, and incidentally led to its correction in certain respects, it being pointed out that certain varieties which we had included as under ⅞ inch staple normally average a length above that class, especially Barsi and Nagar and Hyderabad Gaorani, while on the other hand other varieties—*i.e.*, Comilla, Burma, etc.—which we had placed in the ⅞-inch category should be transferred to the lower grade. In revising this table we have therefore given effect to these corrections, and the opportunity has also been taken to bring the

table down to date. The result is to bring out a really surprising total of what would in India be called long-staple cotton, the total amounting in recent years to above 2½ million bales of 400 pounds. The question is whether the whole of this should be included as part of the world's supplies of Grade II. cotton in Table VII. above. Even converting the figures to 500-pound bales, the totals are still so large as to make one a little dubious whether the figures do not give an exaggerated idea of India's contribution to that grade. We feel, however, that the only logical course is to give the figures as they stand with this explanation and caution.

The result of the inclusion of these larger Indian figures is to reduce considerably America's percentage of Grade II., but even so the United States can now claim fully 80 per cent. of the world's supplies of this class of cotton.

Another interesting point in the Indian table is the very high average yield of the crop for the last five years. The division of the crop into short and long staple, and the rapid growth of the latter, suggests a possible reason for this. It will be noted that for the last four years the average yield of the long-staple section has been consistently higher than the short-staple section, though this was seldom true in the previous years. Does this justify the hope that the improved cultivation and better seed selection in the case of the longer-stapled varieties may lead to their giving a higher yield normally? This would be a distinct achievement, because the longer-stapled varieties used to be regarded as giving a smaller yield than the short staple.

TABLE V.—POSITION OF AMERICAN COTTON IN THE WORLD'S SUPPLIES.

Bales of 500 Lbs. Approximately (000's Omitted).	1914.	1920.	1921.	1922.	1923.	1924.	1925
World's crops	27,919	21,466	16,664	20,319	20,216	26,777	30,199
American	16,738	13,700	8,360	10,320	10,811	14,497	17,100
Percentage of total	60	64	50	51	51	54	57
Grade II. Medium.							
Russia	*500*	*50*	*20*	*20*	*100*	*150*	*300*
China	*250*	*150*	*150*	*200*	*200*	*200*	*200*
Brazil	406	453	559	568	612	619	750
Mexico	112	211	155	151	159	267	215
Other South American	14	38	61	71	120	148	*200*
Africa (Non-British)	3	10	15	20	33	35	*35*
Empire Crops:							
Africa (East, West, and South)	47	102	64	99	148	230	243
Malta and Cyprus	5	2	2	1	2	3	3
Australasia and Iraq	—	1	2	8	10	14	11
India	*750*	904	1,350	1,749	1,882	2,083	2,154
American	16,738	13,700	8,360	10,320	10,811	14,497	17,100
Total	18,825	15,621	10,738	13,207	14,077	18,246	21,211
American per cent. of Grade II.	89·0	87·6	78·0	78·1	77·1	79·5	80·7

Figures in italics are estimates.

TABLE VI.—INDIAN COTTON CROP: AREA, CROP, AND YIELD PER ACRE BY VARIETIES.

(000's *Omitted Throughout in Area and Crop Figures*)

Varieties.	1915–16.			1916–17.			1917–18.			1918–19			1919–20.			1920–21.		
	Area (in Acres)	*Crop (bales of 400 lbs.)*	*Yield per Acre (lbs.).*	*Area.*	*Crop.*	*Yield per Acre.*	*Area.*	*Crop.*	*Yield per Acre.*	*Area.*	*Crop*	*Yield per Acre*	*Area*	*Crop*	*Yield per Acre*	*Area.*	*Crop*	*Yield per Acre.*
I. *Mainly under $\frac{7}{8}$ Inch Staple:*																		
Oomra (Khandeish, Central India, Berar, and Central Provinces)	6,282	1,662	106	7,331	1,342	73	7,477	899	48	6,766	1,169	69	7,663	1,953	101	7,119	844	47
Dhollera	1,180	150	51	2,061	585	114	3,413	680	80	1,775	118	27	2.205	510	93	2,408	453	75
Bengal Sind (United Provinces, Rajputana, Sind Punjab, etc.)	2,262	591	105	3,103	930	120	4,066	669	66	3,146	880	112	4,453	1,366	123	4,164	1,093	105
Comilla, Burma, etc.	329	68	83	351	75	85	379	94	99	497	116	93	787	165	84	507	81	64
Total under $\frac{7}{8}$ inch staple ..	10,053	2,471	98	12,846	2,932	91	15.335	2,342	61	12,184	2,283	75	15.108	3.994	105	14,198	2,471	70
Per cent. of total crop ..	56·8	66·1	—	59·0	65·1	—	60·8	58·6	—	57·8	57·3	—	64·7	68·8	—	66·5	68·6	—
II. *Mainly $\frac{7}{8}$ Inch Staple and Above:*																		
Broach	1,044	230	88	1,226	304	99	1,346	314	93	1,363	169	50	1,283	308	96	1,273	199	63
Coompta Dharwar	1.031	231	90	1,385	260	75	1,781	356	80	1,551	252	65	1,318	296	90	1,301	216	66
Western and Northern .. .	1,350	172	51	1,583	238	60	1,596	169	42	1,812	232	51	1,766	274	62	1,431	147	41
Coconada	251	35	56	275	48	70	261	29	44	272	51	75	28	3	43	240	42	70
Tinnevelly	563	84	59	647	134	83	577	99	69	1,385	344	99	956	234	98	948	242	102
Salem and Cambodia . ..	281	32	46	334	47	56	649	217	134									
Barsi and Nagar	3,168	483	61	3.449	539	62	3,643	474	52	2,471	647	105	1,736	352	81	1,057	162	61
Hyderabad Gaorani				(Included in Barsi and Nagar)									1,158	335	116	893	122	55
Total $\frac{7}{8}$ inch staple and above ..	7,693	1,267	66	8,899	1.570	70	9,853	1,658	67	8,854	1.695	77	8,245	1,802	88	7,143	1,130	63
Per cent. of total crop	43·2	33·9	—	41·0	34·9	—	39·2	41·4	—	42·2	42·7	—	35·3	31·2	—	33·5	31·4	—
Grand total	17,746	3,738	84	21,745	4,502	83	25,188	4,000	64	21,038	3,978	76	23.353	5,796	99	21,341	3,601	67

TABLE VI.—INDIAN COTTON CROP: AREA, CROP, AND YIELD PER ACRE BY VARIETIES.—*Continued.*

(*000's Omitted Throughout in Area and Crop Figures.*)

Varieties.	1921–22.			1922–23.			1923–24.			1924–25.			1925–26.		
	Area.	*Crop.*	*Yield per Acre.*	*Area.*	*Crop.*	*Yield per Acre.*	*Area.*	*Crop.*	*Yield per Acre.*	*Area.*	*Crop.*	*Yield per Acre.*	*Area.*	*Crop.*	*Yield per Acre.*
I. *Mainly under ⅞ Inch Staple:*															
Oomra (Khandeish, Central India, Berar, and Central Provinces)	6.686	1,643	99	7,679	1,627	85	7,891	1,552	79	8,768	1,674	77	8,901	1,546	69
Dhollera	1,845	455	99	2,014	489	97	2,127	311	58	2,578	628	97	3,156	626	79
Bengal Sind (United Provinces, Rajputana, Sind Punjab, etc.)	2,280	622	109	2,428	695	74	2,847	862	121	3,671	1,070	117	3,783	1,050	111
Comilla, Burma, etc.	459	72	63	419	78	74	440	85	77	497	112	90	580	124	86
Total under ⅞ inch staple	11,270	2.792	99	12,540	2,889	92	13,305	2,810	84	15,514	3,484	90	16,420	3,346	82
Per cent. of total crop	61·2	62·3	—	57·5	56·9	—	56·3	54·3	—	57·5	57·5	—	58·8	55·3	—
II. *Mainly ⅞ Inch Staple and Above:*															
Punjab (American)	401	79	79	382	117	123	604	235	156	964	363	151	1,066	328	123
Sind (American)	(Included under Sind Punjab)			7	4	229	5	3	240	16	4	100	7	2	114
Broach	949	168	71	1,130	281	99	1,233	215	70	1,355	345	102	1,387	324	93
Coompta Dharwar	926	212	92	1,130	189	67	1,696	254	60	1,951	333	68	1,726	314	73
Western and Northern ..	1,125	142	50	1,657	167	40	1,949	182	37	2,199	345	63	2,207	373	68
Coconada	212	42	79	279	55	79	263	51	78	291	57	78	302	57	75
Tinnevelly	894	238	106	1,048	141	112	611	157	103	621	164	106	595	166	112
Salem					23		211	25	47	235	32	54	196	34	69
Cambodia					130		369	151	164	442	183	166	416	164	158
Barsi and Nagar	1,549	386	100	2,180	628	115	1,990	579	116	3,213	778	97	3,638	930	102
Hyderabad Gaorani	1,125	420	149	1,439	451	125	1.400	500	143						
Total ⅞ inch staple and above ..	7,181	1,687	94	9.252	2,186	95	10,331	2,352	92	11.287	2,604	92	11,540	2,692	93
Per cent. of total crop	38·8	37·7	—	42·5	43·1	—	43·7	45·7	—	42·5	42·5	—	41·2	44·7	—
Grand total	18,451	4,479	97	21,792	5,075	93	23,636	5,162	87	26,801	6,088	91	27,960	6,038	86

TABLE VII.—EMPIRE COTTON CROPS FOR SEVEN YEARS 1919–25, EXCLUDING INDIA

(In bales of 400 lbs.)

COUNTRY.	1918–19.	1919–20.	1920–21	1921–22	1922–23.	1923–24.	1924–25	1925–26. Estimates.	
(1) Anglo-Egyptian Sudan ..	15,997	23,160	30,519	24,074	28,306	47,652	44,912	116,108	(1)
(2) Gold Coast	52	—	61	49	15	93	—	*	(2)
(3) Nigeria	17,500	16,200	30,000	15,096	16,811	25,694	39,137	44,000	(3)
(4) Uganda	36,530	47,694	81,365	48,290	88,046	128,604	196,038	170,000	(4)
(5) Kenya	100	100	500	417	1,200	1,653	2,250	2,125	(5)
(6) Nyasaland	2,591	2,026	4,615	5,422	4,036	6,873	7,718	7,500	(6)
(7) Northern Rhodesia	56	35	100	80	102	500	379	3,533	(7)
(8) Southern Rhodesia	—	—	—	—	—	1,650	4,907	12,500	(8)
(9) Tanganyika	—	—	7,500	7,327	7,175	11,434	18,793	20,718	(9)
10) Union of South Africa and Swaziland	1,911	2,737	2,923	2,740	6,523	8,730	16,936	31,250	(10)
11) West Indies	6,137	6,205	4,833	4,113	5,254	4,290	4,184	5,000	(11)
12) Queensland	31	38	792	3,140	9,344	11,850	15,156	10,000	(12)
13) Cyprus	1,000	3,325	2,687	2,547	1,505	2,233	3,320	*	(13)
14) Malta	315	343	266	582	193	118	573	782	(14)
15) Iraq	—	—	60	60	300	1,100	2,400	3,500	(15)
16) Fiji	—	—	—	—	83	153	123	333	(16)
17) Ceylon	—	—	—	—	49	324	121	784	(17)
	82,220	101,863	166,221	113 937	168,942	252,951	356,947	428,133†	
		Percentage Increase 24·0.	*Percentage Increase* 63·1	*Percentage Decrease* 31·4	*Percentage Increase* 48·2	*Percentage Increase* 49·7	*Percentage Increase* 41·1		

* No estimates as yet received. † Total incomplete

NOTES ON CURRENT LITERATURE

COTTON IN INDIA.

270. India. (Abstr. from the *Manch. Guard. Coml. Ann. Rev.*, 1925, pubd. January, 1926, p. 48.) "With the disappearance of the Excise duty, and therefore the removal of its only substantial grievance against the Government, the Indian cotton mill industry will be forced hereafter to rely for further improvements on measures within its own volition. The four main problems still confronting the industry, in order of importance, are (1) the attainment of a higher standard of efficiency and probity in management; (2) a curtailment of the 'absenteeism' among the mill employees, especially immediately after pay-day, which involves substantial and economically unjustifiable additions to the cost of production; (3) the high rate of exchange; (4) Japanese competition, which can be combated, fiscally, only by denouncing the Indo-Japanese Trade Convention of 1905, or alternatively imposing a preferential tariff on imported piece goods and yarn. In relation to the Bombay mills in particular, it is evident that the abolition of the Excise duty concurrently with the re-establishment of the former wage standard merely restores the situation existent before the heavy accumulation of mill stocks forced mill-owners, in effect, to declare a look-out. It follows that the process of rehabilitating the Indian cotton industry is only beginning, and that the most formidable difficulties have still to be faced."

271. Indian Science Congress, 1926. At a joint discussion on "Some Modern Problems of Scientific Research for the Improvement of Cotton Growing" the following papers were given: "The Study of the Cotton Fibre," by A. J. Turner; "The Improvement of the Plant," by Trevor Trought; "Reduction of the Loss caused by Diseases," by G. S. Kulkarni; "Reduction of the Loss caused by Insects," by M. A. Husain; "Special Problems of Cotton-Growing on the Black Soils of the Peninsula," by A. Howard and H. A. Hyde; "Special Problems of Cotton-Growing in Canal Colonies," by W. Roberts. All the papers are well worth careful perusal, but owing to the limits of space are too long to abstract in the present number.

272. Indian Cotton: Cost Factors. By W. Kuske. (Abstr. from *Journ. of Text. Inst.*, xvii., 1, 1926, A27.) The high price of Indian cotton is attributed to high cost of production and to gold inflation, and the relation of the latter factor to cost is discussed.

273. Tractors in the Northern Circle of the Central Provinces. By J. H. Ritchie. (Abstr. from *Agr. Journ. of India*, vol. xxi., 1, 1926, p. 27.) In the north of the Central Provinces a very large area of land has gone out of cultivation owing to the deep-rooted and obnoxious weed *kans* grass (*Saccharum spontaneum*). Tractors have been successfully used to bring such land once more into cultivation. It is quite intractable to the ordinary plough.

274. Historical Reference to Cotton in India. (*Anglo-Gujarati Qrtrly. Journ.*, xviii., 3, 1926, and subsequent number.) A brief historical account of cotton in India from early times to the present day.

275. The Romance of the Plough. (*Agr. Journ. of India*, vol. xxi., 1, 1926, p. 62.)

COTTON IN THE EMPIRE (EXCLUDING INDIA).

276. The following Reports have recently been received:

Fiji. "Annual Report for 1924."

India. "Report of the Millowners' Association, Ahmedabad, 1924-25."

Queensland. "Annual Report of the Department of Agriculture and Stock, 1924-25."

Sierra Leone. "Annual Report of the Lands and Forests Department, 1924."

St. Kitts-Nevis. "Report on the Agricultural Department, 1924-25."

Tanganyika. "Report of the Department of Agriculture for the Year 1924-25."

The Imperial College of Science and Technology, London. "Eighteenth Annual Report, 1925."

277. Cotton Growing in the Empire. (Abstr. from *Manch. Guard.*, April 1, 1926.) An account of a tour made by Mr. W. H. Himbury, General Manager of the British Cotton Growing Association, and Mr. J. M. Thomas, a member of the Council of the Association, through the cotton-growing districts of India, Kenya, Uganda, Tanganyika, Sudan, and Egypt. Mr. Himbury reports that what he has seen has greatly strengthened his conviction that there is a great future for cotton-growing in the Empire, and that the time is coming nearer when the needs of Lancashire will be supplied from this source.

278. AFRICA: East Africa. We have received from the Department of Overseas Trade a copy of the "Report on the Trade and Commerce of East Africa," September, 1925, by C. Kemp. Cotton is dealt with on pp. 18 to 20.

279. Kenya. *Tours in the Native Reserves, and Native Development in Kenya.* By E. B. Denham. (Cmd. 2573. Obtainable from H.M. Stationery Office. Price 6d.)

280. Nigeria. *A Survey of Factors affecting the Development of the Cotton Plant in the Oyo and Abeokuta Provinces of Southern Nigeria.* By T. G. Mason and C. H. Wright. (Abstr. from the *Fourth Ann. Bull. of the Dept. of Agr. of Nigeria*, 1925, pp. 3-31.)

Summary.—(1) Experiments have been carried out (1924-25) in two areas, one in the Oyo Province and the other in the Abeokuta Province. These experiments have not revealed any significant differences in the yielding capacities of American and Native cotton.

(2) The results indicate that the total number of open bolls per acre produced by American cotton on the various plots was in a large measure a function of the specific conductivity of the 1 to 5 soil extract. Differences in the percentages of bolls shed, spacing, etc., were apparently of subsidiary importance.

(3) In Native cotton, on the other hand, the total number of open bolls was influenced not only by the salt content of the soil but also by the hygroscopic coefficient of the subsoil. The numbers of bolls were probably also affected by the damage to the plant body caused by *Helopeltis* and *Pseudomonas;* this damage is probably correlated with the hygroscopic coefficients, since compensatory growth is not usually marked on light soils.

(4) Damage sustained in the later phases of the bolls' development resulted in great loss of crop in both types of cotton. Damage due to bollworms was considerable in both cottons, but loss from the internal boll disease was much more pronounced in American cotton than in Native, whereas it seems probable that the importance of anthracnose was second only to bollworms in reducing the yield of Native cotton.

(5) In American cotton the staining of the lint was intimately associated with the internal boll disease; in Native cotton, on the other hand, anthracnose was

probably a more important factor than the internal boll disease in the staining of the lint.

(6) A tendency on the part of Native cotton to postpone flowering until the termination of the rains was noted. This tendency has not been observed in American cotton.

(7) A new disease of cotton, for which the term "leaf roll" has been suggested, was discovered in the course of the work.

281. RHODESIA (SOUTHERN). *Assisted Cotton-Growing.* (Abstr. from the *Afr. Cott. Journ.*, vol. i., 27, 1926, p. 9.) At its last meeting the Buluwayo Chamber of Commerce adopted a resolution to the effect "That in view of the great benefits which the whole community would derive from the successful growing of cotton in this Colony, this Congress recommends the Government to grant, where necessary, all reasonable financial assistance to cotton growers to enable them to test thoroughly the crop and its economic possibilities in Southern Rhodesia."

282. From the *Rhod. Agr. Journ.*, vol. xxiii., 2, 1926, p. 112, we quote the following with reference to cotton: "The total acreage planted to cotton in 1924-25 was 62,858 acres, yielding 5,888,462 lbs. of seed cotton, or an average of 93 lbs. per acre. The highest district yield was Darwin, with 200 lbs. per acre from 145 acres, but the districts giving the best results were:

	Acres.	*Total Yield.* (*Lbs.*)	*Yield per Acre.* (*Lbs.*)
Mazoe	15,838	3,125,629	197
Lomagundi	7,454	1,246,630	167
Nyamandhlovu	1,127	181,775	161

With data only extending over two years, and those years of such widely differing extremes in the matter of rainfall, it is impossible to indicate which portions of the country are likely to prove most suitable for the cultivation of cotton, but it is noteworthy that, as in other crops, Mazoe and Lomagundi are well to the fore.

No figures are available as to the acreage likely to be planted during 1925-26, but from such reports as are available farmers on the whole do not appear to be discouraged as to the ultimate success of this crop, and a number appear to be trying the effects of ratooning with a view to obtaining an earlier harvest. Apart from other arguments against this procedure, it remains to be proved whether the crop will not mature too early and the opening bolls be affected by the normal February rains.

The total number of farmers who planted cotton during the season under review was 1,287, or 51·38 per cent. of the farmers in the country."

283. *The Cotton-Breeding Station at Gatooma.* By G. S. Cameron. (Abstr. from *Rhod. Agr. Journ.*, xxiii., 2, 1926, p. 120.) The author states that by the existing arrangements the Cotton-Breeding Station at Gatooma is financed by the Government, with the exception of the technical staff, who are employed by the Empire Cotton Growing Corporation, whose senior representative is responsible for the general outline of experimental and investigational work, while the plant breeder in charge of the station is, in turn, responsible for the carrying out of the same.

An outline of the first year's programme, 1925-26, is given under the headings of Improvement Work, New Cotton Varieties under Trial, Miscellaneous Cottons grown for Observation, Spacing Tests, and Manurial Trials. (Cf. *E. C. G. Rev.*, vol. iii., No. 2, 1926, p. 160 *et seq.*)

284. SOUTH AFRICA. *Cotton-Growing Costs.* By Max Olbbe. (Abstr. from the *Afr. Cott. Journ.*, i., 21, 1925, p. 3.) The author stresses the need for the use of fertilizers as an aid to cotton cultivation in South Africa. An account is given of

experiments carried out by Messrs. Berney and Bloxam at Potgietersrust in 1923-24 and 1924-25 to test the value of rock phosphate as a fertilizer used in conjunction with superphosphate, and also in conjunction with bone meal and superphosphate. The results showed that increased profits can be made by the addition of rock phosphate to the fertilizer mixture. A table giving the costs, returns, and net profit per acre is also included in the article.

285. *Cotton Insect Investigations: Staff.* (Extracted from the *Journ. of the Dpt. of Agr.*, March, 1926, p. 199.) "The entomologists employed on cotton insect problems include the following: Geo. C. Haines, who is now giving full time to the direction of the work, under the Chief, Division of Entomology; A. J. Smith, who is stationed at Rustenburg, and has charge of life-history work, and is giving special attention to the cotton bollworms; T. C. Cairns, who has been transferred from tsetse-fly work in Zululand, and is now stationed at Klaserie, Eastern Transvaal, where he is making a special study of bollworms in that district; J. S. Taylor, who arrived from England on January 9, 1926. As soon as Mr. Taylor becomes acquainted with our cotton pests and conditions, he will be assigned a subject for study. The fifth cotton entomologist has not yet been appointed, but it is expected that the post will soon be filled."

286. *Labour for Cotton.* (Abstr. from the *Afr. Cott. Journ.*, vol. i., **26**, 1926, p 11.) The Central Co-operative Cotton Exchange have addressed a letter to the Prime Minister appealing for assistance in providing a sufficiency of native labour for the growing and picking of the cotton crop. Among the suggestions put forward in the letter to ensure an adequate supply of native labour are the following:

1. That the vacation period of native schools be made to coincide with and extend over the cotton-picking season, in order that the cheapest and most easily procurable labour—that of girls and boys—may be available in the cotton fields during that period.
2. That the period for which recruited labour may be engaged be extended.
3. That strict medical examination of recruited natives be enforced.

287. *The Reaction of Some Transvaal Soils.* By J. J. Theron. (Abstr. in *Exp. Sta. Rec.*, 53, **7**, 1925, p. 616.)

288. SUDAN. *Cotton-Growing in the Sudan.* By P. F. Martin. (Abstr. from the *Text. Recorder*, xliii., **516**, 1926, p. 86.) An interesting article, with excellent illustrations supplied by the Sudan Government.

289. *Impressions of the Sudan.* (*East Africa*, vol. ii., No. 70, 1926, and subsequent numbers.) An interesting account of a trip through the Sudan, with a good deal of reference to cotton cultivation.

290. TANGANYIKA TERRITORY. In the *Ann. Rpt. Dpt. of Agr.*, 1924-25, recently received, much information concerning cotton cultivation in the Territory is given under the following heads: Seed distribution to natives; ploughing; marketing improvement and extension; experimental work at the Agricultural Stations; cotton crop statistics; control of pests and diseases.

291. UGANDA. *New Railways in Uganda.* (Abstr. from *East Africa*, vol. ii., **76**, 1926, p. 520.) Construction work is now in progress on the extension of the Uasin Gishu branch of the Kenya-Uganda Railway to a junction with the Busoga Railway (which links Jinja on Lake Victoria with Namasagali on Lake Kioga) at Mbulamuti Station. When this extension is completed, towards the end of next year, the main line of the Kenya-Uganda system will be physically connected with the Busoga Railway, leaving only the short Port Bell Kampala line, seven miles long, detached from the railway network of Kenya and Uganda.

292. AUSTRALIA AND POLYNESIA. *Experimental Work on Cotton on Certain Queensland State Farms during* 1924-25. By G. Evans, C.I.E. (*Queensland Agr. Journ.*, xxv., **2**, 1926, p. 133). A valuable report, which does not lend itself to the purpose of abstracting.

293. QUEENSLAND. From the report of Mr. G. Evans, Director of Cotton Culture, published in the *Ann. Rpt. of the Dept. of Agr. and Stock*, 1924-25, we learn that; taken as a whole, the 1924-25 cotton season, while undoubtedly better than the two previous ones, proved somewhat disappointing after the exceptional promise of the early spring. An account is given of the experimental work carried out at the Callide Cotton Research Station, Biloela, at the Monal Creek Experimental Farm, and at the Gatton Agriculture College. The demonstration and field work, and the work of the Government Cotton Classer, Mr. L. L. Gudge, and his assistants are also described. Grants in aid of cotton research work have been promised by the Empire Cotton Growing Corporation and by the Commonwealth Government. During the season under review insect pests and diseases were responsible for some damage. The remedy for these in infected areas is stated to be in the hands of the farmers, who should remove and burn the plants as soon as the last profitable picking has been taken, and observe a close season during which no cotton shall be above ground.

294. *Cotton Thinning and Spacing Experiments for the Season* 1924-25. By W. G. Wells. (Abstr. from *Queensl. Agr. Journ.*, xxiv., **6**, 1925, p. 532.) A description, with tables, of the thinning and spacing experiments carried out by the Department of Agriculture and Stock at the State Farms at Monal Creek, Home Hill, and Biloela. The author concludes by stating that "the problem of spacing the rows and the plants is a very difficult one, and a system which gives the maximum results one season may be unsuitable entirely for the same soil under different climatic conditions. Each grower should experiment carefully to determine the distances which will give the best average yields over a series of years, rather than try to obtain a system which will give the maximum yields each season."

295. TASMANIA. *Cotton Mill.* (Abstr. from *Text. Recorder*, xliii., **516**, 1926, k. 101.) "The Government of Tasmania has received information that a large tract of land has been purchased in the island by an English firm for the purpose of building a textile factory on the site. The development is an important one for the antipodes, since it is proposed to manufacture Queensland cotton, which, it is believed, will find a ready market throughout Australia. Cotton experts are to be sent to Tasmania. It is hoped that within the next six months the factory will be erected and a start made. Substantial support has been promised."

296. WESTERN AUSTRALIA. *Cotton-Planting.* By I. Thomas. (*Journ. Dpt. Agr. W. Austr.*, 1924, **1**; *Bot. Abstr.*, 1925, **14**, 1263. Abstr. from *Summ. of Curr. Lit.*, vi., **3**, 1926, E. 7.) Experiments with cotton at the Chapman Experiment Farm are described. The experiments were planned to determine the earliest date at which cotton could be sown, the advantage of early sowing being the presence of more moisture than is normally available to a later sown crop. Sowing prior to September was unsuccessful because the ground was too cold to permit germination, although there was abundant moisture at this time. By September the ground was warm enough to permit germination, but the air temperature was too cold for vigorous growth. Later, the temperature was high enough for satisfactory growth, but the moisture was deficient.

297. FIJI. From the *Ann. Rpt. Dept. of Agr. for* 1924, recently received, we quote the following from the report of the Assistant Superintendent of Agriculture, with reference to cotton: "During the year the Colony has been favoured by a visit from Mr. G. Evans, Director of Cotton Culture, Queensland, when I accompanied

him on a tour of inspection, covering a month, to the leeward of Vitilevu and Vanualevu, which are considered to be the most favourable for the cultivation of cotton. A comprehensive report was submitted by Mr. Evans, and the recommendations contained therein have been fully considered, and, wherever possible, are being given effect to.

"After the thorough inspection made on this visit, it would seem that cotton-growing by peasant Indian cultivators around Lautoka, where the ginnery is established, is now successfully launched. It provides occupation and a small cash return for a number of Indian families, who live away from the sugar-cane area controlled by the Colonial Sugar Refining Company, and it has besides the tendency of stabilizing a population of rural workers many of whom can find work in the cane fields.

"The Colonial Sugar Refining Company have signified their intention of refusing to carry cotton on their railway line after this season; other means of transport will, therefore, have to be organized in order to keep the industry alive in that part of the main island. This will retard the development of cotton-growing in that zone, but it is not expected while high prices rule for cotton that it will wipe out this promising industry. Private enterprise has been much stimulated by the prospects offered, and it is probable that cotton cultivation, with the help of better equipment than the small Indian cultivator can afford, will soon open up estates now left unproductive."

298. WEST INDIES. *Cotton Research Station, Trinidad.* From *Trop. Agriculture* of April, 1926, we quote the following with reference to the progress that is being made with the work in connection with the Cotton Research Station, Trinidad: "At the time of writing the work on the development of the Research Station is well advanced. When the land was acquired some of it was under cacao, some under coconuts, and the remainder, the larger part, was open pasture which had grown up to bush. The land has been cleared and most of it has been planted with sugar-cane which, it is expected, will yield some cash return, and will be the means of putting the land into good condition for the planting of cotton at a later date. A sufficient area of cleared land has been left for the planting of cotton for immediate needs, with the advent of the wet season in May or June next. Roads have been laid out and metalled, surface drains made, a water supply located, and fences erected. Four houses of the bungalow type have been built and are nearing completion. Two of these are being used for residences and two as laboratories. Another house is to be built, and this, with a house on the Station, completes the accommodation for residence of the Staff.

"The work of laying out and developing the Station has been under the direction and supervision of Mr. W. Nowell, Assistant Director of the Trinidad Department of Agriculture, while the planning and building of the houses has been under the direction of Dr. H. M. Leake, Principal of the College."

COTTON IN THE UNITED STATES.

299. AMERICA. We have received from the Department of Overseas Trade a copy of the "Report on the Finance, Industry and Commerce of the United States of America, 1925," by J. Joyce Broderick. Cotton is dealt with on pp. 61-62.

300. COTTON BALE U.S.A. TARE STANDARDIZATION. By E. A. Beveridge. (*Int. Cott. Bull.*, 4, 1925, p. 56. Abstr. *Summ. of Curr. Lit.*, vi., 5, 1926, E. 29.)

301. A LARGE COTTON CROP IN AMERICA. By G. W. Foosho. (*Manch. Guard. Coml. Ann. Rev.*, 1925, p. 62.)

302. AMERICAN COTTON CROP ESTIMATING. By J. A. Todd. (*Manch. Guard. Coml.*, December 31, 1925, p. 701.)

303. "Half and Half" Cotton Cultivation in U.S.A. By A. S. Pearse. (Abstr. from *Summ. of Curr. Lit.*, vi., **5**, 1926, E. 24.) With the high parity for Indian cotton, with which it comes into competition, the "Half and Half" variety, yielding staple of only ⅝ to ⅞ inch, has been popular in East Texas, Arkansas, Oklahoma, Georgia, Louisiana, and Alabama. Originally the ginning percentage was 48 per cent., but through mixing of seed and lack of selection it has gone down to 42 or even 38 per cent. Especially in East Texas the yield per acre is satisfactory, and the high ginning percentage has led to its extensive growth.

304. Production of Acala Cotton in the San Joaquin Valley of California. By W. B. Camp. (*Dpt. Circ. No. 357 of the U.S. Dpt. of Agr.*, 1925.) An interesting and well-illustrated account of the cultivation of Acala cotton in the San Joaquin Valley, California, given under the following heads: Cultural conditions in the San Joaquin Valley; Choice of the Acala variety of cotton; One-variety communities; Developing supplies of pure seed; Acreage of cotton in relation to that of other crops; Selection of land; Cotton in young orchards and vineyards; Need of thorough levelling; Preparation of land; Planting and germination; Cultivation; Thinning and spacing; Spring and summer irrigation; Late irrigation; Picking methods and costs; Precautions in ginning; Classing and marketing.

305. Field Crops Experiments in Louisiana. By A. F. Kidder *et al.* (Abstr. from *Exp. Sta. Rec.*, **53**, No. 6, 1925, p. 528.) Boll studies with cotton gave indications of the importance of protecting boll setting while blooming is increasing to its maximum, and that weevil control after this maximum is reached is relatively less important so far as maturity of the crop is concerned. The rainfall recorded did not seem to affect boll setting injuriously. Plants spaced 8 to 12 inches apart averaged twenty or more bolls per row foot, whereas those spaced 20 to 30 inches apart produced only eleven bolls per row foot.

COTTON IN FOREIGN COUNTRIES.

306. We have received from the Association Cotonnière Coloniale a copy of Bulletin No. 74.

307. Argentine. We have received from the Department of Overseas Trade a copy of the "Rpt. on the Finan. Coml. and Econ. Conditions of the Argentine Republic," 1925, by H. O. Chalkley. In the section devoted to Cotton it is stated that the northern provinces of the republic have climate, rainfall or irrigation, and soil which are entirely suitable for cotton production over very large areas; cotton cultivation during the next few years will, however, depend largely on the possibility of obtaining suitable labour. There has not yet been sufficient experience to estimate an eventual average cost of production, but under present conditions it is placed at something under half the average cost in the United States. There is, however, at present a far greater difference in the cost of marketing Argentine cotton, and consequently in the margin of difference between interior and Liverpool prices; to reduce this margin a producers' co-operative marketing scheme has been proposed by the Ministry of Agriculture.

Cotton production suffered a set-back in the season 1924-25, owing to drought, pests, etc., and although a record area was sown the yield averaged only 400 kilos per hectare, which is considered to be 50 per cent. below normal.

308. Cotton Production: Argentina. (*Journ. Roy. Soc. Arts.*, 1926, **74**, Abstr. from *Summ. of Curr. Lit.*, vi., **3**, 1926, E. 7.) At the present time the "Gran Chaco" is the great centre of cotton production in Argentina. Allowing for the available areas in other provinces a total area of 165,000 square miles offers pros-

pects for future cotton-growing. Costs of production are relatively low, and the only serious trouble is the attack of locusts. By erecting corrugated iron barriers to the progress of the insect during the hopping stage and burying the insects in trenches, the National Department claims to have destroyed during the last season over 300 million pounds weight of locusts. The average yield of cotton per acre is 227 lbs.

309. BRAZIL. We have received from the Department of Overseas Trade a copy of the "Rpt. on the Econ. and Financial Conditions in Brazil, 1925," by E. Hambloch, from which we quote the following with regard to cotton: "The crop estimated by the Brazil Cotton Service in 1924-25 was 131,118 tons, or 582,746 bales of 500 lbs., compared with 124,875 tons, or 550,000 bales in 1923-24."

310. COTTON PRODUCTION: BRAZIL. By E. Schultze. (*Leipziger Wochens. Text. Ind.*, 1925, **40.** Abstr. in *Summ. of Curr. Lit.*, v., **19**, 1925, E. 94.)

311. COTTON CULTIVATION: CHINA. By Ben Y. Lee. (Abstr. in *Summ. of Curr. Lit.*, vi., **3**, 1926, E. 9.)

312. COTTON CULTIVATION: CHINA. By C. C. Chen. (Abstr. in *Summ. of Curr. Lit.*, vi., **3**, 1926, E. 10.)

313. JAPAN: COTTON INDUSTRY EXPANSION. (*Text. World*, 1925, **68**, 2617. Abstr. from *Summ. of Curr. Lit.*, vi., **5**, 1926, M. 7.) A twofold increase in spindles, a sevenfold increase in looms, an increased consumption of cotton by 1,000,000 bales, a hundred per cent. increase in yarn production, and a sevenfold increase in cloth production is reported by the Japan Cotton Spinners' Association as occurring between 1905 and 1924. Yarn production of counts above 20's is almost 63 per cent. of the total—namely, 2,000,000 bales—and though yarn exports are down to pre-war level, over 50 per cent. of these exported yarns is over 20's.

314. JAPAN'S OUTPUT AND TRADE IN COTTON YARN AND CLOTH. (*Anglo-Gujarati Journ.*, xviii., **3**, 1926, p. 133.)

315. PERU. We have received from the editor of the *West Coast Leader* a copy of the Third Annual Cotton Number. This is a very interesting publication, which should be read by all interested in Peruvian cotton. The chief exports of Peru in 1924 were:

Cotton	Value Lp. 6,458,470
Petroleum	6,019,855
Minerals	5,173,011
Sugar	4,976,430

In the season 1924-25, 221,442 bales of cotton were used in Britain, and realized an average price of about 21½d.

316. COTTON CULTIVATION: PERU. (Abstr. in *Summ. of Curr. Lit.*, vi., **3**, 1926, E. 11.)

317. THE FUTURE OF PERUVIAN COTTON. (*Text. Recorder*, xliii., **516**, 1926, p. 83.)

318. COTTON CULTIVATION IN SPAIN. By Santiago Trias. (*Int. Cott. Bull.*, 1925, **3**, p. 630.)

319. COTTON CULTIVATION IN TRANSCAUCASIA. (*Int. Cott. Bull.*, 1925, **4**, p. 115.)

320. COTTON PRODUCTION IN THE TURKISH REPUBLIC. By H. Husni Bey. (*Int. Cott. Bull.*, 1925, **3**, p. 632.)

CULTIVATION AND MACHINERY: IRRIGATION, ETC.

321. Delinting and Sterilization of Cotton Seed by the Sulphuric Acid Treatment. By C. B. Hardenburg. (Abstr. from the *S. Afr. Cott. Growers' Journ.*, ii., 5, 1925, p. 25.) Describes the process of delinting cotton seed by means of strong sulphuric acid, carried out at the works of the African Explosives and Industries, Ltd., Umbogintwini, Natal. The advantages claimed for this treatment are as follows: (1) It is effective in checking cotton pests and diseases; (2) considerably less delinted seed is required for planting, as burning off the fuzz renders the seed smooth so that it runs easily through the planter and does not stick together; (3) removal of the lint and the light oily film on the seed-coat hastens germination considerably; (4) all immature seeds, which might germinate and produce weakly plants, are destroyed, and only vigorous seedlings are produced; (5) plots planted with sterilised seed mature earlier and give a greater yield, the increase amounting to from 25 to 28 per cent. in favour of delinted seed.

322. Studies on Treatment of Cotton Seed. By S. G. Lehman. (N. *Carolina Agr. Exp. Sta.*, Tech. Bull. 26, 1925. Abstr. in the *Rev. of App. Mycol.*, v., 2, 1926, p. 90.) This is a very detailed account of the author's investigations instituted in 1920, on the control of cotton anthracnose (*Glomerella gossypii*) by seed treatment. The seeds were heated in quantities of 50 or 100 in an electric oven provided with a constant temperature regulator, and examined individually, after germination, to determine the extent of fungus infection. The results of the various experiments are summarized in the long and detailed abstract given in the *Rev. of App. Mycol.* of February, 1926, p. 90.

323. A Machine for Treating Cotton Seed with Sulphuric Acid. By J. G. Brown and F. Gibson. (*Ariz. Agr. Exp. Sta. Bull.* 105, 1925. Abstr. from *Rev. App. Mycol.*, v., 2, 1926, p. 92.) The authors describe in detail the construction of a simple and relatively inexpensive machine for the bulk treatment of cotton seed with sulphuric acid for the purpose of delinting, stimulating germination, and destroying seed-borne parasites (*e.g.*, *Bacterium malvacearum*). The type described is capable of dealing with 50 gallons of seed every three to fifteen minutes, according to variety and the grade of the acid. It costs about $100 to construct and, allowing for cost of the acid, labour, and depreciation, the cost per acre is about 18 to 20 cents.

324. Cotton Seed Beds: Value of Early Preparation. (Abstr. from *Queensl. Agr. Journ.*, xxiv., 5, 1925, p. 423.) Mr. W. G. Wells, the Cotton Specialist, emphasizes the importance of the early preparation of seed beds by ploughing and harrowing the ground before the rains, in order to conserve the moisture in the soil, and thus ensure a good strike of cotton.

325. Tractor or Bullock. By A. Classen. (*Cyprus Agr. Journ.*, xxi., 1, 1926, p. 20.) A previous article under this title, by the same author, appeared in the *Cyprus Agr. Journ.*, xx., 4, 1925, p. 127 (*cf.* Abstr. 214). The present article discusses the kind of tractor or motor-plough required, with notes on cost of working and repairs.

326. Comparative Trials with Ratoon and Annual Upland Cotton carried out by the Queensland Department of Agriculture in 1924-25. By G. Evans, C.I.E. (Abstr. from the *Queensl. Agr. Journ.*, xxiv., 6, 1925, p. 523.) The conclusions arrived at by the author, as the result of the experiments, are summarized as follows:

1. The annual cotton plots in each case gave very much bigger yields and greater profits than the ratoon.

2. Ratoon cotton puts out a number of suckers which spread horizontally and thus hinder cultivation by horse implements. Hand hoeing is prohibitive

owing to the expense involved, with the consequence that weeds overcome the cotton and the soil moisture is rapidly used up.

3. Ratoon plots act as breeding grounds for the principal cotton pests early in the season.

4. Picking of ratoon cotton is rendered difficult owing to the low spreading nature of the plants.

5. Ratoon cotton is considered by experts to be inferior to annual cotton in drag and lustre, with somewhat shorter staple and more irregularity in the length of the fibres.

327. Soil Acidity. By C. R. von Stieglitz. (*Queensl. Agr. Journ.*, xxiv., **5**, 1925, p. 468.)

328. Synthetic Farmyard Manure. (Abstr. from *Agr. Journ. of India*, xxi., **1**, 1926, p. 65.) Describes the Adco process of the Agricultural Development Company for manufacturing synthetic manure.

329. South Africa. *Cotton Fertiliser Trials.* By T. D. Hall. (Abstr. from *Journ. of Dpt. of Agr.*, March, 1926, p. 234.) An illustrated account of experiments carried out at Naboomspruit, Transvaal, in the 1924-25 cotton season. Information is given under the following heads: Description and composition of the soil; Pot-culture experiment; Crop rotation and fertilizer experiment; Fertilizer treatments; Cultural methods; Cost of fertilizers at Naboomspruit; Action of lime on the soil; Recommendations based on the experiment; What fertilizer to use; American experience in fertilizing cotton, etc.

330. Cotton Plant: Manuring. By W. H. Appleton and H. B. Helms. (*Journ. of Amer. Soc. of Agron.*, 1925, **17**. Abstr. from *Journ. of Text. Inst.*, xvii., **2**, 1926, A. 31.) Greenhouse experiments on the rate of absorption by cotton of nitrogen applied in the form of sodium nitrate are described. The nitrate was applied at the rate of 600 pounds per acre, 14, 40, and 61 days after planting, and absorption was complete in 36, 14 and 11 days respectively. Thus, when nitrate is applied to cotton 14 days after planting the plants are not sufficiently developed to absorb it rapidly, and considerable amounts may be lost by leaching. Such loss may be diminished considerably by delaying application to a later stage of growth.

331. Thinning Out Cotton: The Best Spacing to Adopt for Queensland Conditions. By J. D. Young. (Abstr. from the *Aust. Cott. Grower, Farmer and Dairyman*, vol. i., **2**, 1925, p. 3.) In this article the author recommends that in inland districts on medium types of soils, single plants should be spaced from 18 to 24 inches apart, in rows 4 feet apart, and on richer types of soils, which retain moisture well, from 15 to 20 inches between single plants in the row. He also gives directions as to the best method to use in thinning out the cotton plants.

332. Cotton Classing. By L. L. Gudge, Chief Government Cotton Classer. (Abstr. from the *Queensl. Agr. Journ.*, xxv., **2**, 1926, p. 115.) A useful article which should be read by all interested.

333. Cotton Ginning. By G. S. Meloy. (*Farmers' Bull. No.* 1465 *of the U.S. Dpt. of Agr.*, 1925.) This bulletin, which is profusely illustrated, contains a general discussion of those mechanical processes of ginning which are important to farmers. Only saw gins are treated, as only a small part of the cotton crop is ginned by any other method. The purpose is to bring to the attention of cotton producers, especially in those communities where co-operative handling and marketing of cotton is possible, the numerous benefits to be obtained by keeping the seed pure and by eliminating a portion of the losses caused by indifferent preparation of cotton for the market. Special attention is called to the careless

preparation of the American bale of cotton, the seeming indifference to this matter shown by the farmer, the buyer, and others handling it, and the losses arising from such indifference.

334. COTTON CLASSED IN THE FIELD: PRODUCTION STANDARDIZED BY MAINTAINING UNIFORM VARIETIES. By O. F. Cook. (Abstr. from *Journ. of Hered.*, xvii., 1926, p. 3.) An excellent article by one of the best cotton experts, pointing out first of all the great difficulties that confront the grader, the desirability of his being a man of temperate habits and pleasant home life (to prevent too many "bad days"), and more especially the difficulties that arise from mixing of different grades of cotton in the same bale. This emphasizes the desirability of "one district, one variety," a system which Mr. E. C. Green tried to introduce into Brazil in 1913.

335. AN INVESTIGATION INTO THE RELATIVE UTILITY AND THE RELIABILITY OF VARIOUS METHODS OF COMPARING THE YIELDS OF COTTON FROM EXPERIMENTAL PLOTS. By R. Thomas and K. Sawhney. (*Memoir No.* 11, 1925, *Dpt. of Agr. Iraq.*) Much valuable information is given in this Memoir under the following heads: *Part I.* Introductory, Historical; Object of enquiry; Method of collecting material; Raw material; Mathematical methods used. *Part II.* Mutual relations between the various units of yield; Effect of averaging the yields; Figures of ginning outturn as obtained from the produce of plots as a whole, compared with corresponding figures obtained by ginning the produce of "Observation Groups"; "Observation Groups" as a source of information regarding the maturing habit of a number of varieties of cotton; Recapitulation. *Part III.* Statistical constants of the mean yields; Four-Line Variotal Test compared with the Main Varietal Test with reference to the variability of the plot and the row yields; Summary; Literature cited.

DISEASES, PESTS, AND INJURIES, AND THEIR TREATMENT.

336. BOLL WEEVIL CONTROL. (*Rev. Appld. Entomol.*, **13**, 1925, Series A. 635. Abstr. from *Summ. of Curr. Lit.*, vi., **1**, 1926, E. 5.) The losses sustained by the American cotton crops of 1921 and 1922 as a result of attack by boll weevil were estimated at about £200,000,000. The American Cotton Association, therefore, undertook the leadership of a general campaign, as a result of which 933 cotton demonstration farms of 10 acres were established in 1923. The growers were responsible for the success of the control measures, applied under simple and practical instructions. Many letters indicating the success of the campaign are quoted. In one of these it is stated that four good applications of calcium arsenate will result in a bale of cotton per acre on good land under heavy weevil infestation. Using poison, 1,250 lbs. of seed cotton per acre were obtained as compared with 700 lbs. from the same type of land without poison. It has been proved conclusively that the plan of culture and weevil control as applied under the supervision of the Association increases the yield per acre by one-third. If the work could be extended to all the infested counties the weevil would soon be definitely controlled.

337. BOLL WEEVIL CONTROL IN SOUTH CAROLINA. By C. B. Nickels. (Abstr. from *Journ. of Text. Inst.*, xvii., **2**, 1926, A. 59.) Calcium arsenate dusted on cotton resulted in an average extra profit of 29.85 dollars on six farms. Two calcium arsenate-molasses mixtures, in seven applications at weekly intervals, yielded no return. No profit was secured from the use of the Florida stripping method, and its application cost 1.51 dollars to the acre.

338. PROGRESS REPORT ON STUDIES ON BOLL WEEVIL CONTROL UNDER SOUTH CAROLINA CONDITIONS. (*S. Carolina Agr. Exp. Sta. Bull.* 61, 1925. Abstr. in *Rev. of App. Ent.*, A., vol. xiv., **2**, 1926, p. 74.)

339. CALCIUM ARSENATE. TOXICITY. By S. B. Hendricks *et al.* (*Ind. Eng. Chem.*, 1926, **18**. Abstr. from *Summ. of Curr. Lit.*, vi., **3**, 1926, E. 14.) A study of the relative toxicity of the calcium arsenates shows that in relation to the boll weevil the basic arsenates have a constant toxicity, but the acid arsenates are much more toxic.

340. SEASONAL VARIATION IN PINK BOLLWORM ATTACK ON COTTON IN EGYPT IN THE YEARS 1916-24. By C. B. Williams. (*Bull. No.* 67 *Min. of Agr. Egypt.*) The conclusion arrived at by the author, as the result of his investigations, is that the development of the pink bollworm attack is directly limited by the state of development of the cotton crop. In other words, the pink bollworm is apparently ready to develop at any time during the spring and summer, and merely awaits the arrival of the cotton at a certain stage to be able to infest a certain percentage of the bolls, probably in some mathematical law of progression. Small or large alterations in the cotton crop are reflected in the development of the pink bollworm attack.

341. THE PINK BOLLWORM (*Platyedra gossypiella* Saund.). By E. Ballard (Abstr. from the *Queensl. Agr. Journ.*, xxv., **1**, 1926, p. 23.) A detailed and well-illustrated account of the insect and of the methods of control.

342. SOUTH AFRICA. *Pink Bollworm of Cotton in Nyasaland.* (Abstr. from the *Journ. of the Dpt. of Agr.*, March, 1926, p. 201.) The Division of Entomology, South Africa, has been officially informed by the Department of Agriculture, Zomba, Nyasaland, that the pink bollworm has been found in the northern extremity of the Protectorate. The message states that drastic control measures are being taken. The region concerned has only water communication with the southern districts, and a belt of 150 miles of non-cotton country lies between the areas. Cotton culture must cease in the infested areas, and has been prohibited in the intervening country.

343. PUNJAB. (*Ann. Rpt. of Entomologist to Govt.*, 1924. Abstr. from *Rev. of App. Ent.*, *A.*, vol. xiv., **2**, 1926, p. 89.) The larvæ of *Platyedra gossypiella* Saund. are recorded for the first time as actually feeding on flowers of hollyhock. Some of the larvæ can apparently remain in the resting stage for more than one year, but attempts to breed this species in the laboratory were not successful. Parasites bred from the larvæ include Braconids belonging to the genera *Chelonus*, *Apanteles*, and *Bracon*, and a Chalcid, *Elasmus* sp.

344. SOUTH AFRICA. *Cotton Dusting and Spraying.* (Abstr. from the *Journ. of the Dpt. of Agr.*, March, 1926, p. 200.) An attempt is being made this season in various localities of the bollworm belt of the Transvaal to demonstrate whether dusting with an arsenic will sufficiently control bollworms as to give an increase in the yield of cotton that will cover all the expense of the treatment, and at the same time show a profit. The experiments are being carried out as follows: At each centre plots of cotton, growing on uniform soil, are being dusted with calcium arsenate, half of the plots receiving one application and half three applications of the dust. Record is kept of the amount of poison applied, and the cost of the treatments. Types of dusters similar to those used in the cotton fields of America are being employed. Parallel experiments will be made with dry Bordeaux mixture, which in two cases will also be used as a spray.

345. COTTON STAINERS. By E. Ballard. (*Queensl. Agr. Journ.*, xxv., **1**, 1926, p. 53.) A full account, with notes on treatment.

346. CUTWORMS. By E. Ballard. (Abstr. from *Queensl. Agr. Journ.*, xxv., **1**, 1926, p. 89.) Cutworms are the caterpillar stage of a moth (*Agrotis* sp.). They only feed at night, and hide during the day under the surface of the soil. The grubs

are about 1¼ inches long when full grown, and of a dirty grey-green colour. The usual method of control is to scatter a poisoned bait around the cotton plants. This bait is made as follows: Bran 25 lbs., calcium arsenate, lead arsenate, powder, or Paris green, 1 lb. Mix together and moisten with water and molasses. The mixture must not be too wet, but should just crumble in the fingers. It should be spread at night, or just before dark, at the rate of about 5 lbs. to the acre.

347. COTTON APHID: LIFE HISTORY. By E. M. Patch. (*Science*, **62**, 1925. Abstr. from *Summ. of Curr. Lit.*, vi., **1**, 1926, E. 5.) Experiments conducted with species of the cotton aphid, *Aphis gossypii*, indicate the possibility that the winter host of this pest is the orpine plant, *Sedum telephium*.

348. FORMULÆ OF SOME COMMON INSECTICIDES AND WASHES EMPLOYED AGAINST VARIOUS INSECT PESTS, WITH DIRECTIONS FOR THEIR USE. By D. D'Emmerez de Charmoy and A. Moutia. (Extr. from *Bull. No.* 31 *of the Dpt. of Agr. Mauritius*. Abstr. from *Trop. Agriculturist*, Ceylon, lxv., **6**, 1925, p. 356.) A most useful publication, giving the formulæ for all the common washes and insecticides, which it is often difficult to find at a moment's notice.

349. THE COTTON PLANTATION AND ITS INSECT PROBLEMS. By C. B. Hardenburg. (*South Afr. Cott. Growers' Journ.*, vol. ii., No. 7, 1926, p. 23.)

350. NOTES ON EGYPTIAN COCCIDÆ, WITH DESCRIPTIONS OF NEW SPECIES. By W. J. Hall. (*Tech. and Sci. Serv. Bull. No.* 64 *Min. of Agr. Egypt*. Obtainable from Government Publications Office, Ministry of Finance, Dawawin P.O., Cairo. Price P.T. 5.)

351. NEW CURCULIONIDÆ ATTACKING CULTIVATED PLANTS. By G. A. K. Marshall F.R.S. (Abstr. from the *Bull. of Ent. Res.*, xvi., Pt. 1, 1925, p. 67.) Among the insects described are the following that are stated to be injurious to cotton seedlings in South Africa: *Protostrophus edax*, *Protostrophus lugubris*, and *Protostrophus vorax*. Illustrations of these insects are included in the article.

352. TENTATIVE KEYS TO THE ORDERS AND FAMILIES OF INDIAN INSECTS. By T. Bainbrigge Fletcher. (*Bull. No.* 162, 1925, *of Agr. Res. Inst. Pusa*. Obtainable from Government of India Central Publications Branch, 8, Hastings Street, Calcutta. Price Re. 1-4 or 2s. 3d.)

353. COTTON PESTS: EGYPT, INDIA, MESOPOTAMIA. By B. P. Uvarov. (*Rev. App. Entomol.*, **13**, 1925, Series A. 598. Abstr. from *Summ. of Curr. Lit.*, vi., **1**, 1926, E. 6.) The insect pests of cotton occurring in Egypt, India, and Mesopotamia are reviewed.

354. GOLD COAST. *Rep. of the Entomological Div.* By G. S. Cotterell. (*Rpt. Agr. Dept. Gold Coast*, 1924-25. Abstr. from *Rev. of App. Ent.*, *A.*, vol. xiv., **1**, 1926, p. 9.) The following are recorded as attacking cotton in the Mandated Area of British Togoland: *Sylepta* sp. (cotton leaf roller), which is a minor pest and is heavily parasitized; *Aphis gossypii*, which becomes a serious pest during the dry weather, but disappears with the rains; *Earias* spp., common early in the season; *Helopeltis*, only a pest at the beginning of the season, and disappearing entirely at the end of the rains; *Dysdercus* spp., which are pests of major importance, accounting for 40 to 50 per cent. of the potential yield in some parts; and *Oxycarenus* sp., which does not cause staining, but possibly affects the vitality of the seed.

355. COTTON PESTS IN FRENCH WEST AFRICA: DESCRIPTION. By P. Vayssière and J. Mimeur. (*Rev. of Appld. Entomol.*, **14**, 1926, Series A. 6-9. Abstr. from *Summ. of Curr. Lit.*, vi., **5**, 1926, E. 26.) The life history and control of the following pests of cotton in French West Africa are discussed: *Microtermes* (*Ancistrotermes*) *soudanensis*, which causes the plant to wilt by mining the young stems; *Sphenoptera gossypii*, which is also a stem miner; and *Mylabris affinis* adults,

which devour the petals and stamens of cotton flowers and sometimes enter the buds, though they cause very little damage, and may assist in fertilization. *Nisotra uniformis* and *N. dilecta* are frequently found on the lower surface of leaves of young plants where they destroy the parenchyma. The larvæ of *Chilena obliquata*, which occur in very small numbers, attack the leaves. *Diparopsis castanea* occurs on cotton; *Prodenia litura* attacks the parenchyma of cotton; *Xanthodes intercepta* feeds during the day on both surfaces of the leaves, but is not numerous; *Cosmophila flava* feeds on all species of cotton, but is not abundant; *Diacrisia punctulata* is present in small numbers; *Acrocercops bifasciata* attacks cotton in the cotyledon stage, and *Corcyra cephalonica* attacks stored goods, including cotton seed. In an appendix the characteristics and distribution of *Platyedra gossypiella*, for which treatment of the seed with chloropicrin is an effective control measure, are discussed. *Tenebrio guineensis*, two species of *Myllocercus*, and *Alcides gossypii* occur, but do not rank as pests.

356. CEYLON. *Rept. of the Entomologist.* By J. C. Hutson. (*Ceylon Adm. Rpts. Dpt. of Agr*, 1924. Abstr. from *Rev. of App. Ent., A.*, vol. xiv., **1**, 1926, p. 39.) Cotton pests were: *Platyedra gossypiella* (pink bollworm), which is becoming prevalent in the Southern Province, *Cosmophila indica*, *Earias* spp., *Sylepta derogata*, *Euptcrote geminata*, *Stauropus alternus*, which was recorded for the first time on cotton in Ceylon, and *Dysdercus cingulatus*.

357. SIERRA LEONE. From the *Ann. Rpt. of the Lands and Forests Dpt.*, 1924, recently received, we learn that the cotton crop was only under observation during December, but several pests were encountered, among which may be mentioned cotton-stainers, locusts, aphis, leaf-hoppers, mealybugs, scale insects, etc. No pink bollworm has yet been seen, and arrangements have been made for the fumigation of all cotton seed entering the country. Further, it is considered desirable that all seed should be strictly under Government control if this and other foreign pests are to be excluded.

358. TANGANYIKA TERRITORY. *Pests of Cotton.* (Abstr. from the *Ann. Rpt. of the Dpt. of Agr.*, 1924-25.) From the report of the Entomologist we quote the following: "*Anatrachyntis* (*Pyroderces*) sp. appeared in scattered areas in late October and November. In the making of boll counts the pink worms of this moth may be confused with those of *Platyedra*. Distinction, however, is easy in that *Anatrachyntis* is pink while *Platyedra* caterpillars of similar size would still be creamy white, not having advanced sufficiently to assume the later larval colour.

"The effect of the work of cleaning up stems and residues in cotton plantations at the conclusion of seasons 1922 and 1923 has been extremely satisfactory against the cotton weevil, *Apion xanthostylum* Wagn.

"*Tragiscoschema nigroscripta* Fairm., is responsible for the greater share of the cotton stem girdling observable.

"Cotton aphis, *A. gossypii*, was generally present in the past season, but seasonable weather and the natural enemies of aphids may be relied upon to prevent important damage.

"Three species of cotton stainer (*Dysdercus nigrofasciatus* St., *D. fasciatus* Sign., and *D. cardinalis* Gerst) are generally present throughout the cotton-growing districts.

"With regard to pink boll worm (*Platyedra gossypiella* Saund.) it is stated that the situation is not as satisfactory as it might be, owing to the fact that the native in too many instances has shown complete disregard of his instructions in the matter of picking, preparation, and uprooting of cotton in relation to the control of pests. As a consequence, the countryside contains much abandoned cotton in places, and the good work of non-native planters and of industrious, progressive natives is rendered useless."

359. Some Protozoa found in Certain South African Soils—III., IV. By H. B. Fantham and N. F. Paterson. (*S. Afr. Journ. Sci.*, xx. and xxi. Abstr. in *Exp. Sta. Rec.*, vii., **53**, 1925, p. 618.)

360. Cotton Anthracnose: Control. By C. A. Ludwig. (*S. Carolina Exp. Sta. Bull., No.* 222, 1925. Abstr. from *Summ. of Curr. Lit.*, vi., **3**, 1926, E. 15.) Anthracnose (*Colletotrichum gossypii*) is one of the most important cotton diseases and occurs in most of the cotton-growing regions of the world. It is largely transmitted, from season to season, by infected seed. Attempts to develop a quick, practical method of destroying the fungus in the seed have not been successful. Effective control measures consist of such means as the selection of seed from healthy stalks not growing near diseased ones, ploughing in of diseased stalks in the fall or following a rotation, ginning in a clean gin, delinting with strong sulphuric acid, and storing infected seed for at least two years before planting to allow the fungus to die. The experimental work reported is a study of some of the environmental features which affect the life of the fungus in stored, infected seed. The results show that the seed becomes free of infection in storage. Under laboratory conditions the action proceeds very slowly at first, but becomes rapid when the seed is about a year old. By the second spring after picking the infection has practically disappeared. Storage in a very moist atmosphere leads to the early death of the fungus, but the seed becomes musty and fails to germinate. Storage in a very dry atmosphere greatly prolongs the life of the fungus. Alternate storage in very dry and very moist air was of no advantage. Delinted and sterilized seed has the initial infection cut down to a low figure, and that remaining in the seed seems to become eliminated a few months sooner than in untreated seed.

361. Cotton Fungi: Life History. By N. E. Stevens. (*Bot. Centrlbl.*, **148**, 1925. Abstr. from *Summ. of Curr. Lit.*, vi., **3**, 1926, A. 3.) *Diplodia gossypina* can be distinguished physiologically from the allied *Diplodia natalensis* only by its higher temperature maximum; it is related to a member of the *Pseudosphæriaceæ* provisionally named *Physalospora gossypina* Stevens, and the latter is differentiated from *P. malorum* by somewhat larger perithecium and ascospores. The only form of *Botryosphæria* known to be parasitic on *Gossypium* is *B. ribis* (Grossenbacher and Duggar).

362. Control of Angular Leafspot of Cotton. By S. F. A. (Abstr. from *Trop. Agriculture*, iii., **1**, 1926, p. 8.) In this article the author describes the angular leafspot disease of cotton, which is caused by *Bacterium malvacearum* E. F. Smith, and states that the control method recommended by the South Carolina Experiment Station is delinting the cotton seed with strong sulphuric acid, washing, immersion for ten minutes in 1 part per 1,000 corrosive sublimate, washing and drying. An account is also given of experiments carried out in St. Vincent in 1923 to control angular leafspot of cotton.

363. The Life History and Relationships of Diplodia Gossypina. (*Mycologia*, xvii., **5**, 1925. Abstr. in *Rev. of App. Mycol.*, v., **2**, 1926, p. 90.)

364. Cotton "Damping-off" Disease: Cause. By H. R. Rosen. (*Rev. of App. Mycol.*, **5**, 1926. Abstr. from *Summ. of Curr. Lit.*, vi., **3**, 1926, E. 15.) It has generally been assumed that damping-off of cotton is chiefly due to *Rhizoctonia*, but observations are described from which it appears that *Fusarium vasinfectum* plays an important part in its causation. There is little difference in the symptoms produced by these two organisms, but the discoloration due to *F. vasinfectum* is almost black, and occasionally extends upwards through the xylem beyond the rotted collar, whilst that caused by *Rhizoctonia* is reddish, wine-coloured, or purplish, and usually localized at the collar. At about 28° C

Rhizoctonia makes much more vigorous growth than *F. vasinfectum*. *F. vasinfectum* attacks through the roots, and may be expected to cause most severe damage at rather high soil and air temperatures, whereas the *Rhizoctonia* symptoms are likely to be more pronounced in cool, damp weather.

365. PRELIMINARY INVESTIGATIONS OF THE PARASITISM OF CERTAIN FUNGI CAUSING BOLL ROTS OF COTTON. By T. Laycock. (Abstr. from the *Fourth Ann. Bull. of the Agr. Dept. Nigeria*, 1925, pp. 32-49.) The three diseases dealt with in this article are the *internal boll disease*, *anthracnose boll rot*, and *Fusarium boll rot*. The results of the experiments are summarized below:

Internal Boll Disease.—1. Internal boll disease at Ibadan is caused by a fungus at present undetermined, but probably allied to *Nematospora* and corresponding to Nowell's Type C. (The balance of evidence favours the assumption that other fungi also contribute their quota to the general damage.)

2. The small incidence of disease when stainers are absent or when "sterilized" stainers attack cotton bolls, and its presence to a much larger extent when bolls are punctured by stainers from the field, clearly indicates that the disease is introduced through punctures and is probably actually carried by the stainer.

3. No external symptoms of disease are produced, but the contents of the boll are disorganized to a varying degree. In the case of early infection the loss may be complete. With later infection the loss is represented by low grade, stained lint.

4. Infection has been completely demonstrated about six days after the boll was punctured.

5. The fungus has not yet been isolated from cotton stainers.

6. No alternative hosts of the fungus have been discovered in Nigeria.

Anthracnose Boll Rot.—1. Anthracnose disease assumes in certain seasons epidemic proportions, and its onset appears to depend upon adverse environmental conditions—*e.g.*, the sudden setting in of severe "harmattan" conditions.

2. Under these conditions, and probably aided by insect agency, it produces complete rotting of the bolls.

3. It appears to be a facultative parasite.

4. It is not the causal agent producing die-back, and it appears to be restricted almost entirely to the bolls.

5. In cases of slight attack it is responsible for a certain amount of "staining," although in severe attacks the lint becomes a dark greyish colour and quite unsaleable.

Fusarium Boll Rot.—1. Fusarium occurs on the vegetative and reproductive parts of the cotton plant.

2. It is a saprophyte, and damp conditions, together with prior wounding of the host plant due to insects and bacteria, favour its development.

3. It is not so virulent a boll-rotting factor as is anthracnose.

4. It is not responsible for "wilting" of cotton in Nigeria.

366. COTTON PLANT DISEASES IN U.S.A. By W. Robinson. (Abstr. from *Summ. of Curr. Lit.*, vi., **5**, 1926, E. 28.) A short report of a lecture on some diseases of cotton observed in the plantations of North and South Carolina. In addition to the usual diseases of cotton, other diseases studied were those caused by species of *Alternaria* and *Ascochyta gossypii*. These have not hitherto been of serious consequence in the United States, but the latter is now spreading.

367. PLANT PATHOLOGY. By J. G. Brown and F. Gibson. (From the *Thirty-third Ann. Rpt. Ariz. Agr. Exp. Sta.* Abstr. from the *Rev. of App. Mycol.*, v., **2**, 1926, p. 82.) Experiments to test the effect of soil alkali on the susceptibility of Pima-Egyptian cotton to the black-arm disease (*Bacterium malvacearum*) were commenced, treated and untreated, naturally infected seed being sown in various

localities with differing soil types. Preliminary experiments showed that the treatment of the seed with concentrated sulphuric acid gave effective control of the disease and was superior to formaldehyde, corrosive sublimate, or hot water.

Although the same lot of heavily infected seed was used, no black arm appeared in the area in which the soil contained strong alkali, whereas in an area on alkali-free soil the crop was severely attacked, an examination of 273 plants showing 226 to be infected. It is thought that possibly the less succulent and more woody plants that grow in the former area were able to resist the infection.

BREEDING, GENERAL BOTANY, ETC.

368. Express Cotton: Description. By E. C. Ewing. (Abstr. in *Summ. of Curr. Lit.*, vi., **3**, 1926, E. 13.)

369. Tanguis Cotton: Description. (Abstr. from *Summ. of Curr. Lit.*, vi., **5**, 1926, E. 21.) The seed is a very small one of a dark brown colour, with small and characteristic horizontal lines, and with a little hairy tail at the end. Its principal advantages are uniformity, ease in classification, and distinctness from every other variety. In yield it exceeds all other Peruvian types, and the smallness of the seed results in a greater ginning outturn—namely, from 40 to 42 per cent. In whiteness and quality it is also superior, and the plant has a great cultural advantage in being wilt resistant.

370. Sea Island Cotton: Inheritance of Corolla Colour. By L. H. Burd. (Abstr. from *Trop. Agriculture*, vol. iii., **3**, 1926, p. 56.) During the season 1923 three plants with quite white flowers were noticed in a plot of pure strain A.N. cotton, their petal colour standing out in clear contrast to the full golden yellow colour of the normal flowers. A considerable quantity of selfed seed was secured from these plants, and the crop in the following season showed that the new type was breeding true. It was found that the white-flowered strain had a shorter lint length than the normal A.N. cotton, and experiments were carried out to determine the possible relation between flower colour and lint length. From the results obtained from these experiments it would appear that there is evidently no tendency for the white colour to be associated with either long or short lint. It is curious that though the two characters, white flowered and short lint, both arose, as far as is known, at the same time, they were apparently inherited entirely independently of one another.

371. Report on the Cotton Breeding Operations in Queensland. By W. G. Wells. (Abstr. from *Queensl. Agr. Journ.*, xxv., **1**, 1926, p. 31.) An interesting report of the progress made in the cultivation of Durango cotton in Queensland from its introduction in 1921 up to 1925. Much information is also given in the article regarding the following: Breeding operations, Durango plant types; Durango progeny centres 1925-26; Technique of laboratory investigations of selections; Investigations in other Upland cottons; Community "One Variety" production.

372. Hypertrophied Lenticels on the Roots of Cotton Plants. By J. Templeton. (*Min. of Agr. Egypt. Tech. and Sci. Serv. Bull.* 59, 1926.) *Summary.*—Hypertrophied lenticels were found to occur on the roots of cotton plants when growing in very wet soil. The date of appearance of these structures, where, as in Egypt, artificial irrigation is practised, is dependent on the irrigations given, the nature of the soil, and the height of the "water table." It is suggested that this date, which will vary in different districts according to the above factors, might be taken as an indication when to reduce the amount of water given at later irrigations, or alternatively, when to lengthen the periods between them. As a

result of experiment it is concluded that, while excessive soil moisture may result in hypertrophy of root lenticels by increasing general sap pressure, the degree of hypertrophy is determined by the supply of oxygen available to the roots.

373. The Function of Lint Hairs in the Life History of the Cotton Plant. By N. W. Barritt. (*Ann. App. Biol.*, ii., 1924. Abstr. from *Exp. Sta. Rec.*, **53**, 1925, 7, p. 633.) The evolution of lint hairs may be considered a special adaptation to climatic conditions. Even to-day, notwithstanding the artificial extension of cotton areas, the varieties with most highly developed lint (*e.g.*, Sea Island and Egyptian) are to be found only in climates with well-marked regular seasons, whilst the varieties with more fuzzy types of lint are found in more erratic climates.

374. The Reaction of the Cotton Plant. By J. A. Harris *et al.* (*Science*, **61**, 1925, No. 1568. Abstr. from *Exp. Sta. Rec.*, **53**, 7, 1925, p. 626.) As a result of hundreds of determinations of the H-ion concentration of mature cotton leaves, the authors found the H-ion concentration well on the acid side of neutrality. The average values for the series of Pima Egyptian cotton grown in 1921 range from pH 5·25 to 5·41, whereas for the series of Upland cotton grown under similar conditions they range from pH 5·35 to 5·46. The H-ion concentration of the tissue fluids of the hybrid is intermediate between that of the Egyptian and Upland types, being on the average lower than the Egyptian and higher than the Upland parent. The only tissue fluids which have been found that have a neutral or significantly alkaline reaction were in Mentzelia of the Loasaceæ and various representatives of the Cucurbitaceæ.

LEGISLATION.

375. Australia. *Proclamation No.* 149 of November 25, 1925, prohibits the importation of cotton seed or cotton lint into Australia subject to certain conditions.

376. Cyprus. (Abstr. from the *Cyprus Agr. Journ.*, xxi., **1**, 1926, p. 28.) An Order dated May 13, 1925, provides that all cotton seed, raw cotton, cotton refuse, etc., be imported into Cyprus through the port of Famagusta, accompanied by a statutory declaration by the consignor, and that it be disinfected as prescribed by the Director of Agriculture.

377. India. *Notification No.* 1493-*Agri.* of November 14, 1925, regulates the importation into British India of American cotton.

Notification No. 1560-*Agri.* of November 26, 1925, amends clause (*a*) of paragraph 2 of Notification No. 1493-A. of November 14, 1925.

Notification No. 1561-*Agri.* of November 26, 1925, amends clause (*c*) of paragraph 2 of Notification No. 1493-A. of November 14, 1925.

Notification No. 4388/24, dated November 26, 1925. Rules for the detention and disinfection of American cotton.

Notification No. 76-*Agri.* of January 14, 1926, further amends clause (*a*) of paragraph 2 of Notification No. 1493-A. of November 14, 1925.

Notification No. 144-*Agri.* of January 26, 1926, amends paragraph 1 of Notification No. 1561-A. of November 26, 1925.

378. Kenya. *Ordinance No.* 18 of September, 1925, amending the Cotton (Tax) Ordinance, 1923, provides for the exemption by the Governor in Council of any district, or districts, in the Colony from the application of this Ordinance.

379. Nyasaland. *Notice No.* 288 of December 31, 1925, prohibits the sowing of cotton seed in "cotton quarantine areas" or the conveyance of seed cotton or cotton seed out of such areas without the written permission of the Director of

Agriculture. Provision is also made for the burning of all cotton plants, and for a "close season" of two years from the completion of the burning, on all cotton plantations where any disease or insect pest of a serious nature exists.

Notice No. 289 of December 31, 1925, proclaims a certain area in the Northern Province to be a "cotton quarantine area."

Notice No. 15 of January 30, 1926, prohibits the sowing of cotton seed within the North Nyasa District, and provides for the uprooting and burning of all cotton plants in this District before February 28, 1926.

380. PAPUA. *Ordinance No.* 11 of September, 1925, may be cited as the *Cotton Ordinance*, 1925, and includes regulations for all or any purposes tending to the improvement of the cotton-growing industry in the Territory.

381. QUEENSLAND. *An Order in Council* of January 14, 1926, provides for the acquisition by the Government of all seed cotton grown in the State of Queensland before July 31, 1926.

A Proclamation of January 14, 1926, states the period of duration of the Government guaranteed price for seed cotton during 1926.

Regulations of January 14, 1926, give the prices guaranteed to growers by the Government for seed cotton during 1926.

382. SAMOA. *The Cotton Ordinance*, 1925 (*Ordinance No. 7 of November 24*, 1925) prohibits (i.) the importation and sowing of cotton seed without the consent of the Administrator or the Director of Agriculture, and (ii.) the growing of ratoon cotton. Regulations dealing with the following matters are also included: Date for destruction of cotton plants and debris; guarantee of prices; acquisition of cotton by the Government; advances to growers; powers of inspection; notification of disease; ginning of cotton.

383. TANGANYIKA TERRITORY. *What to do at the End of the Cotton Season, and Why.* (*Leaflet No. 3 of the Dpt. of Agr.*, 1925.) From this leaflet, which is printed both in English and in the vernacular, we quote the following: "The two following rules now require the careful attention of cotton planters (extract from the Cotton Rules, 1922):

"15. All cotton plants shall be uprooted after the first season's crop has been picked therefrom, and on no account shall they be allowed to remain for a second season, or for more than one year in the ground. All crop residues on the plantation, including the above plants, cotton bolls, seed cotton remaining unsold, etc., shall be burned.

"16. The Director of Agriculture may from time to time fix by notification in the *Gazette* a date prior to which all the previous season's cotton plants, and all plants stated by him in the said notice as those which harbour the pests and diseases of cotton, shall be uprooted and burned in any district, and all such plants shall be uprooted and burned prior to such date, together with all crop residues in or near farms or plantations."

384. UNITED STATES. *Amendment No. 2 to Service and Regulatory Announcements (Agricultural Economics) No.* 91 amends Section 2 of Regulation 11 of the Cotton Futures Act of May 31, 1920.

Amendment No. 2 to Service and Regulatory Announcements (Agricultural Economics) No. 95 amends Section 2 of Regulation 10 and paragraph 2 of Section 1 of Regulation 11 of the Cotton Standards Act of March 4, 1923.

CHEMISTRY AND PHYSICS IN THEIR APPLICATION TO COTTON PROBLEMS.

385. NITROGEN RECUPERATION IN THE SOILS OF THE BOMBAY DECCAN—PART I By D. L Sahasrabuddhe and J. A. Daji. (*Mems. of Dpt. of Agr. in India*, viii., 5, 1925. Chemical Series.) In this article the authors state that "The problem as to how the fertility of Indian soils is maintained in the absence of manure, more particularly in the arid and semi-arid tracts like the Deccan, has always been a difficult one. More especially the maintenance of the available nitrogen is difficult to explain. On the one hand there is a demand on the accumulated stocks of nitrogen from the crop grown. This reaches, in the case of an annual crop of *jowar* (*Andropogon sorghum*) grown without manure, to about 20 lbs. of nitrogen per annum for such a crop (700 lbs. grain and 2,000 lbs. straw) as is commonly produced in the Bombay Deccan. Then there is the annual loss from drainage and from denitrification, while the only apparent return of nitrogen to the soil is from the quantity supplied by rain and dew."

The following conclusions were arrived at: (1) When water is added to the soil within ten days a large quantity of nitrogen is fixed, and this goes on increasing till about thirty-five days and then slowly begins to decrease; (2) up to 30 per cent. of water, the larger the quantity of water the higher the nitrogen fixed; (3) the fixation of nitrogen and nitrification are higher at 40° C. than at lower temperatures; (4) increase in nitrogen takes place both in the presence and absence of light.

386. THE MOISTURE RELATIONS OF COTTON. THE ABSORPTION OF WATER BY COTTONS OF VARIOUS ORIGINS. By A. R. Urquhart and the late A. M. Williams (From vol. iv., 1925, of the *Shirley Institute Memoirs.*)

387. RAW COTTON: OIL SPRAYING. By Borne Scrymser Co. (Abstr. from *Summ. of Curr. Lit.*, vi., 3, 1926, F. 5.) Raw cotton stock is treated or sprayed before the completion of the drawing operation with a non-volatile lubricating oil. Pure mineral oil may be used, or castor or lard oil. The quantity used is between 0·5 and 4 per cent. by weight of the material tested.

388. OIL-SPRAYED COTTON: PROPERTIES. By E. H. Hinckley and R. B. Earle. (Abstr. from *Summ. of Curr. Lit.*, vi., 5, 1926, F. 6.) Oiling is believed to facilitate the cleaning of cotton to a slight extent, but the first distinct advantage is seen in the card-room, where oil eliminates practically all lint in the air. In drawing, the tendency to tangling and thick places is reduced because the fibres slip more readily, and in spinning more twist can be put in without affecting the breaking load of the yarn. Production is said to be greater. In scouring, impurities are removed from oiled material more readily than from untreated material, and cloth made from oiled yarns remains white longer than that from non-sprayed yarns. No difficulty has been encountered in dyeing cloth made from oil-sprayed cotton. The presence of oil does not interfere with coating and rubberizing for the tire trade. The advantages claimed for the process are supported in a subsequent paper. The amount of oil added is so small, and it is so evenly distributed, that its use is no disadvantage to the dyer and finisher.

389. THE TIME FACTOR IN HAIR TESTING. By J. C. Mann and F. T. Peirce. (*Journ. of Text. Inst.*, xvii., 2, 1926, T. 83.)

390. REJTO METHOD OF TEXTILE TESTING. By J. Berosi. (*Text. World*, 67, 1925, No. 17. Abstr. in *Exp. Sta. Rec.*, 53, 7, 1925, p. 634.

CO-OPERATION.

391. CO-OPERATIVE MARKETING OF COTTON. By G. O. Gatlin. (*Bull. No.* 1392 *U.S. Dpt. of Agr.*, 1926.) Describes the background of the movement, contemporary organizations, the American Cotton Growers' Exchange, principles and policies, methods and practices, and costs and prices.

392. CO-OPERATIVE MARKETING OF COTTON IN THE U.S.A. (*Int. Cott. Bull.*, **4**, 1925, pp. 53-56. Abstr. in *Summ. Curr. Lit.*, vi., **5**, 1926, E. 32.)

393. CO-OPERATIVE MARKETING OF COTTON IN THE U.S.A. By A. S. Pearse. (*Int. Cott. Bull.*, 1925, **4**, pp. 2-5, 13. Abstr. in *Summ. of Curr. Lit.*, vi., **5**, 1926, E. 32.)

MISCELLANEOUS.

394. COMMITTEE OF INDUSTRY AND TRADE. We have recently received a note giving some account of the volume entitled "Survey of Industrial Relations," published for the Committee of Industry and Trade in March by His Majesty's Stationery Office. The volume deals with such matters as the growth and distribution of the industrial population, rates of wages and systems of wage payment, hours and other conditions of labour, unemployment, and machinery for dealing with industrial disputes. Not only are the present position and tendencies under these headings dealt with, but information is given as to the main changes which have taken place since the years immediately preceding the war. A considerable amount of information is also given about the position in other countries as regards some of the subjects mentioned—*e g.*, hours of labour and negotiating machinery. The contents of the volume are mainly derived from official sources, and the Committee have prefixed an Introduction calling attention to certain important considerations arising from the Survey. In conclusion, the Committee emphasize the descriptive nature of the volume and express the hope that their impartial ascertainment and publication of authoritative information on the extremely important subject of industrial relations will not only be valuable to those who desire a trustworthy book of reference, but will also conduce towards a better understanding of present-day economic problems by limiting the field of controversy and by facilitating and clarifying discussion.

The volume is obtainable from His Majesty's Stationery Office, or through any bookseller, at the price of 5s.

395. From the *Eighteenth Ann. Rpt. of the Imp. Coll. of Science and Technology*, South Kensington, 1925, we quote the following: "Assistant-Professor Brown, utilizing part of a grant given by the Empire Cotton Growing Corporation to the College, has been enabled to visit the cotton-growing districts of the eastern United States and the West Indies, during the summer vacation. He has thus been enabled to acquire, at first hand, important knowledge on the problems of yield and of disease in one of the most important of tropical economic products, and the experience so gained will be of great value to the Department of Biology."

396. In the *Int. Crop Rpt. and Agr. Statistics*, January, 1926, published by the Int. Inst. of Agr. Rome, cotton is dealt with under the following headings: Areas and Production (p. 32); Exports and Imports (p. 42); Stocks (pp. 46-7). Prices (p. 53).

397. THE COTTON "FUTURE MARKET." By Robert Davies. (*Afr. Cott. Journ.*, vol. i., **25**, 1926, p 5.)

PERSONAL NOTES

OFFICERS ON LEAVE.

When an officer of a colonial Department of Agriculture (or of the allied departments of Irrigation, Transport, etc.) comes "home" on leave, he usually brings with him much information that may be of considerable value to similar officers in other colonies, or to the officers of the Empire Cotton Growing Corporation, who have to collect, collate, and use all possible information relating to cotton. The Corporation would consequently much appreciate the courtesy if Directors of Agriculture and others would be so kind as to inform them, in advance if possible, of the names, probable addresses, and approximate dates of arrival in England of officers coming on leave. This would give the Corporation the opportunity of getting into touch with these officers themselves, and of giving the latter the opportunity of meeting with one another. A further courtesy would be conferred if the officers themselves, upon arrival, would call at, or inform, the offices of the Empire Cotton Growing Corporation, which are at the corner of Millbank and Wood Street (entrance by the first door in Wood Street) immediately opposite to the offices of the Crown Agents for the Colonies.

At the date of writing the following officers are on leave in England from cotton-growing countries:

Barbados	Prof. J. P. d'Albuquerque.
Gold Coast	Mr. C. Saunders.
India	Mr. G. Clarke.
"	Mr. G. R. Hilson.
"	Mr. F. J. Plymen.
"	Mr. A. J. Turner.
"	Mr. W. Youngman.
Kenya Colony	Mr. R. J. Lathbury.
Nigeria	Mr. O. T. Faulkner.
"	Mr. K. T. Rae.
"	Mr. H. B. Waters.
Sierra Leone	Mr. R. R. Glanville.
"	Mr. F. J. Martin.
Sudan	Mr. R. Howison.
Tanganyika	Mr. E. Brand.
"	Mr. L. C. Edwards.
"	Mr. A. M. D. Turnbull.
"	Mr. O. E. Whitehead.
Trinidad	Mr. F. Stell.
Uganda	Mr. S. Simpson.
"	Mr. R. G. Harper.
"	Mr. A. S. Widgery.

The following officers of the Corporation's staff abroad are on leave in this country:

Mr. G. Evans, formerly Director of Cotton Culture, Queensland (until August).
Mr. C. B. R. King, Nyasaland.
Mr. T. McEwen, Nyasaland.

Mr. B. C. Burt, Secretary of the Indian Central Cotton Committee, will arrive in England on leave at the end of July.

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THE LIVERPOOL COTTON ASSOCIATION

BY
A. C NICKSON.
Secretary, Liverpool Cotton Association.

IN writing any article on the work done by the Liverpool Cotton Association, one must naturally mention its foundation.

In Liverpool an Association was formed in 1841 of all the firms that were conducting a business in selling cotton, under the style of the "Cotton Brokers' Association." Most of the business done by these firms was selling cotton consigned to them by shippers, on which business they charged a brokerage. Gradually, however, a number of firms outside this Association commenced business as merchants, buying and selling cotton for their own account, and for a short period two Associations existed in Liverpool—the Brokers and the Merchants. Finally, in 1882, an amalgamation was agreed upon, and the present Liverpool Cotton Association was formed.

The Association at the present time consists of 561 members, who comprise about 300 cotton firms, conducting every class of cotton business.

SPOT COTTON.

The principal business is, of course, the sale of cotton on spot terms, as Liverpool has always been known as, and still is, the greatest Spot Cotton Market in the world. A large stock of every growth of cotton is held by members in warehouse in Liverpool; the largest stock ever held at a time was in 1914, when there were 1,462,112 bales of cotton in Liverpool. Out of this stock, the spinners of Lancashire can fulfil their requirements.

A number of members act as buying brokers for spinners; thus, when a spinner requires cotton, he notifies his broker, who obtains

samples from merchants holding a stock of cotton, and is then in a position to place a selection before the mill manager when he comes to Liverpool. Competition to sell the large Liverpool stock is keen, and the spinner is thus enabled to buy his cotton at the lowest possible price. After a purchase is made the buying broker takes charge of the transaction and acts in the spinner's interest, passing the cotton for quality, arranging the forwarding, and checking the invoices.

For his services the broker charges a minimum commission of ½ per cent. on the value of the transaction, and there is no doubt that the work which is done by a buying broker is essential.

In purchases on spot terms, the price of the cotton is sometimes actually fixed at the time the contract is made, and at other times the cotton is sold " on call " on a certain month—that is, it is agreed in the contract that the price shall be fixed at a certain number of points " on " or " off " a given month for future delivery, the date of the fixing being usually at the option of the buyer. In this way a spinner secures a certain quality of cotton on the basis of futures, and has the privilege of fixing the price at any time convenient to himself.

As regards claims for quality, these must be made before delivery is actually taken, and it is one of the duties of the buying broker to see that the cotton is correct before delivery. After that time the only claim that can be made is for false-packed, or unmerchantable cotton, which cannot be discovered until the bale is actually opened at the mill.

Cotton for Deferred Delivery.

The Association provides forms of contracts by which cotton can be sold on spot terms for delivery at a future date. The rules governing these contracts are on the same basis as those governing spot cotton, but at the time the transaction is made the cotton need not be in Liverpool, the terms of the sale being that the cotton must be of a certain description as compared with the official standards, or equal to an actual " type " of cotton which is kept by the buyer. When the cotton arrives, the out-turn samples are compared with the standard representing the description of cotton bought, or with type, as the case may be, and should any difference arise as regards the quality of the cotton, the matter is decided by arbitration. In the same way as spot cotton, the price may be either fixed at the time the contract is made, or " on call."

An important provision in this contract is that bales tendered

which are not equal to the selling sample, or the description of the cotton contracted for, may be exchanged once, or a second tender may be made within the period allowed for delivery under the contract.

Payment is by cash in ten days, or before delivery if required.

The majority of the business in cotton in spot terms sold to the Lancashire spinner is transacted on this form of contract.

Cotton Sold on C.I.F. Terms.

The Liverpool importer buys most of his cotton from the shipper abroad on C.I.F. terms. In my article in this Journal dated April, 1924, I attempted to outline the method of importing American cotton, and therefore do not think it necessary to go into the matter in detail.

Shippers usually have their own representatives in Liverpool, who are posted by cable as regards cotton offered for shipment, and these agents enter into contracts on behalf of their principals abroad. This system is of recent development, as, before the war, Liverpool merchants usually had their own houses in America, staffed by young Englishmen who bought the cotton from the factor, or farmer, in America. American Immigration Laws, however, have made this practice more and more difficult until, at the present time, very few merchants have their own houses in the States.

The Liverpool merchant is taking an increasing interest in cotton in different Colonies in Africa, and branch offices are gradually being opened in that part of the world.

The Egyptian and Sudan business is also conducted on C.I.F. terms by the Liverpool merchants, who are in close communication with cotton export firms in Alexandria. A number of the large Liverpool houses have branches in Egypt.

The Liverpool Futures Market.

Liverpool, New York, and New Orleans are the three important "Futures" markets for trading in American cotton. There are "Futures" markets in Bombay for East Indian cotton, and Alexandria for Egyptian cotton, but Liverpool is unique in that it has "Futures" contracts for American, for Egyptian, and also for Empire and miscellaneous growths. In the last contract, every growth of cotton, with the exception of certain grades of Egyptian and Sudan, is tenderable, provided, of course, that the quality tendered is within the terms of the contract.

A number of interesting booklets have been written on the subject of cotton futures, and space will hardly permit a detailed account of the various forms of trading.

The minimum contract in American cotton is 100 bales, in Egyptian and Empire, 50 bales. The seller in his contract undertakes to deliver to the buyer in a given month a certain weight of cotton, which the buyer on his part must accept, provided the cotton tendered is within certain grades and staple, which are defined in the contract. The basis of the contract is actual cotton, and unless the contract is closed before maturity, actual cotton must be delivered and accepted.

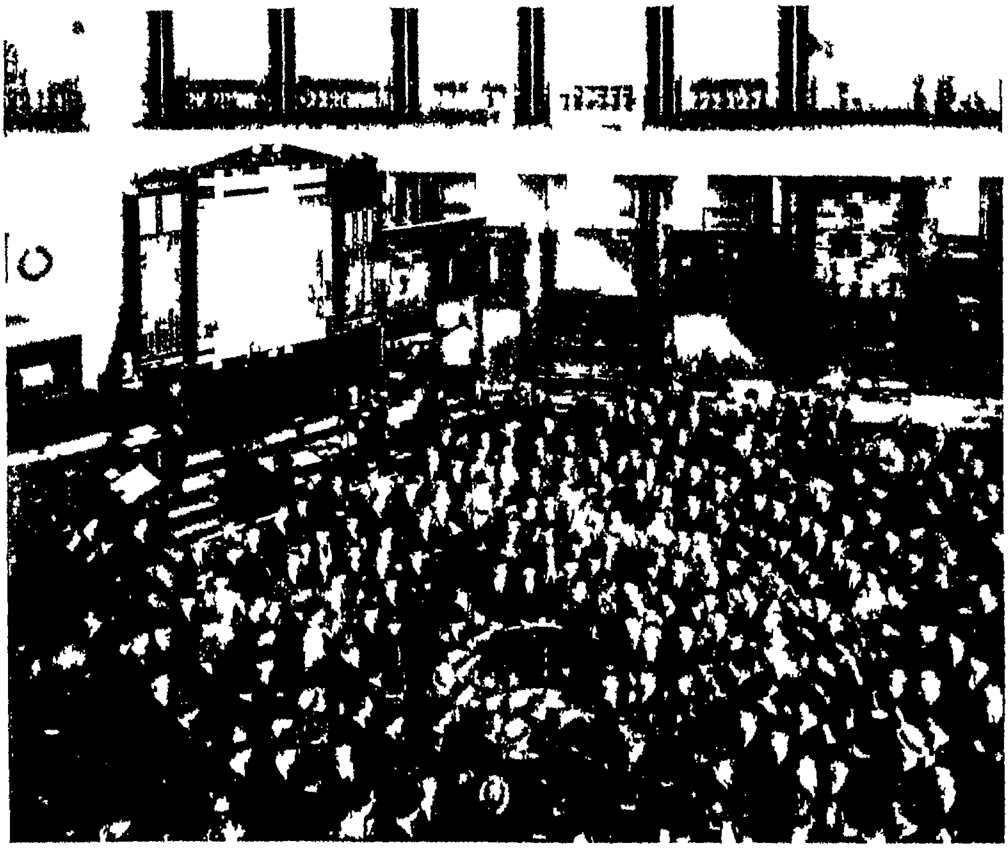
The market is used by almost every section of the cotton trade both at home and abroad for "hedging" purposes, which means that those engaged in the trade can protect themselves from sudden and large fluctuations which take place in the value of cotton. Importers buying cotton for shipment in a certain month which they have not resold, hedge themselves by the sale of futures, and are thus protected against a decline in values before the actual cotton is sold.

In the same way spinners who have not sold their product can protect themselves by a sale in the futures market, and when their yarn is sold they repurchase their hedge, which has acted as a protection during the intervening period.

Orders for the Liverpool futures market are received by Liverpool brokers from all parts of the world, and it is this fact which makes the market one in which a purchase or sale can always be made at the ruling price, large buying or selling orders being transacted without any unreasonable fluctuations taking place.

The contract calls for weekly payment of differences, and these are settled through the medium of the Association Clearing House each Thursday.

The charge made by the broker for transacting an order for futures for account of a non-member client is a minimum of $\frac{1}{2}$ per cent. The Association, however, allows a reduction of this brokerage to a minimum of $\frac{1}{4}$ per cent. to clients who are elected as Associate Members. These are persons in this country who are closely connected with the cotton trade—viz., spinners, importers, yarn agents, etc. The privilege is also extended to persons abroad provided they are members of recognized Cotton Exchanges, such as New York, New Orleans, Havre, Bremen, Bombay, Alexandria, etc., and rules have recently been passed that British subjects resident within the British Empire who are engaged in shipping cotton to this



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country are also eligible, provided they are members of a Cotton Exchange. It is hoped that this regulation will encourage the formation of Cotton Exchanges throughout the Empire where cotton is being grown, and the Association is prepared to give all the advice and help it can to those who undertake the work of establishing those Exchanges.

STANDARDS.

The Association for many years had established Liverpool standards for various growths of cotton; until 1923 these were the standards upon which all European transactions were based. In 1923, however, universal standards for American cotton were agreed upon between the European Exchanges and the Department of Agriculture at Washington, and these have been adopted by the Liverpool Association. The Liverpool standards for all other growths still remain, and are added to as the various new growths for cotton become more important.

ARBITRATION.

All contracts that are made subject to the Articles and Rules of the Association provide that differences or disputes must be settled by arbitration.

The procedure is that each party to the contract appoints a member of the Association to act as Arbitrator, representing his interests, and fully posts him with his view of the case; should the Arbitrators be unable to agree, another member is called in to act as umpire, and his award is communicated to the contracting parties. Either party has, within a stated time, a right of appeal against the award, in the case of quality to the Appeal Committee, or in any other case to the Directors.

Should either party to the contract refuse or neglect to appoint an arbitrator after application to do so has been made to him by the other party to the contract, application may be made to the President of the Association, and if he sees fit he is empowered, under the Rules, to appoint an arbitrator to act for the defaulting party.

There are a number of Appeal Committees, elected each year, for various growths of cotton, and the members of these Committees are experts in the particular growth represented by these Committees. It is difficult to give any figures showing the number of arbitrations on quality which are held in a year, but it would be no exaggeration to state that at least 570,000 bales are adjudicated upon in the Association official arbitration rooms each year.

The Rules provide a further safeguard in the case of quality—that if a contracting party feels that a manifest error has been made by an Appeal Committee in valuing cotton, there is a right of super-appeal to the Directors. The appellant states his case before the Board, and if it is considered that a *prima facie* case has been made out, the Directors appoint a Special Committee to reconsider the case. The Board then issue their award, which is final and must be conformed to by both parties to the contract.

Another important provision with regard to the Liverpool contracts is that they contain a clause to the effect that the contract cannot be cancelled on any ground, and therefore, if it is decided by arbitration that a contract is to be closed, this is done by the buyer invoicing the contract back to the seller at the value in Liverpool on the date of arbitration or appeal, as fixed by arbitration; thus the buyer and seller are placed in the position of being able to replace their contracts.

GENERAL.

The Association is governed by the President, Vice-President, and body of Directors. The President and Vice-President are appointed each year by the members, the Directors also being appointed by the members, retiring by rotation every three years. The numerous Committees are elected each year—namely, Appeal Committees and Committees for fixing the quotations, and the ordinary Committees required to carry on the affairs of the Association, such as the Finance Committee, Committee for making Rules, etc.

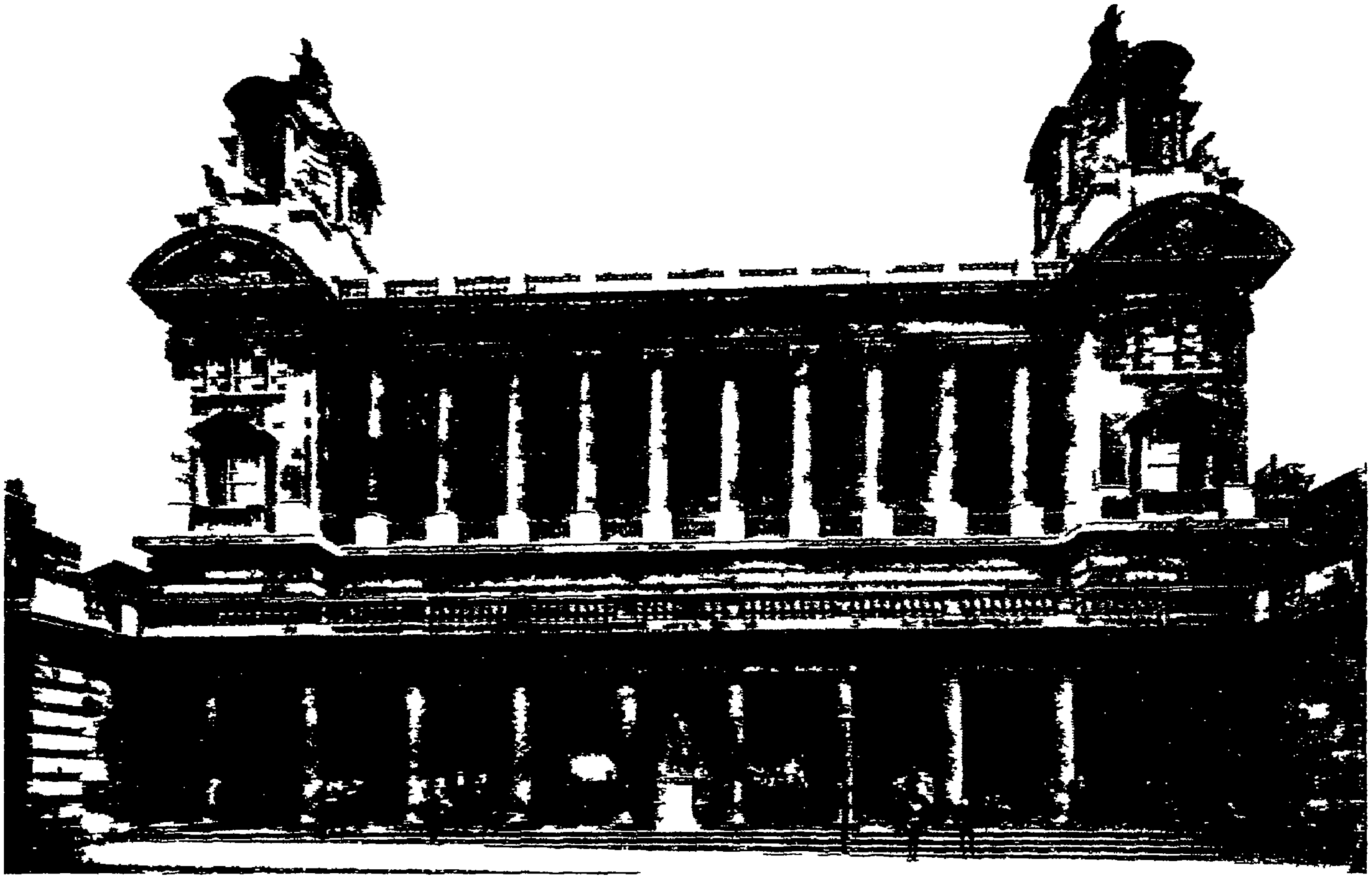
The Directors have very stringent powers over the members in cases of insolvency or misconduct, those being provided for in the Articles of the Association.

All alterations to the Articles and Rules have to be passed, in accordance with the Companies Act, by the members in General Meeting.

The Cotton Exchange building itself, as shown in the annexed photograph, contains the Exchange, where trading in the various futures contracts takes place, and in the building are also innumerable offices for members of the Association. The official Arbitration and Appeal Rooms are also in the building, situated where the best light for judging cotton can be obtained.

Photographs are appended showing trading taking place in the Liverpool Futures Market, and also the Appeal Committee at work judging the quality of American cotton.

Received August, 1926.



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COTTON-GROWING IN THE SOUTHERN SUDAN

BY

R. HEWISON.

Director of Agriculture and Forests, Sudan.

The region generally referred to as the Southern Sudan comprises four provinces—viz., Upper Nile, Nuba Mountains, Bahr el Ghazal, Mongalla. These provinces cover a combined area of some 270,000 square miles, and are inhabited by a population roughly estimated at 3,500,000. They lie approximately between the 12th and 4th parallels north, and the 24th and 34th meridians east. For the present, however, development of cotton-growing is restricted to an area, which for transport can be served by the river, and which lies between the 29th and the 34th meridians.

While the area of these provinces is about one-quarter of the whole country, the population is something over half. The greater density of population is accounted for by the heavier and more dependable rainfall enjoyed in this part of the Sudan. The average annual precipitation ranges from 24 inches in the north, to as much as 52 inches in the extreme south. The greater part of the area actually under discussion lies between the lines representing annual rainfalls of 28 and 40 inches respectively. Generally speaking, there is a definite rainy season, varying in duration and intensity, and followed by an equally definite period of dry weather. In the extreme south the sharp distinction between the rainy and dry season disappears to some extent, and the rainfall is more generally distributed throughout the year.

Other climatic conditions are very favourable to cotton-growing. There is an entire absence of frost, and except in the north, and at high altitudes in the south, a fairly high minimum temperature is characteristic of the region. A moist growing season with a fairly constant range of temperatures enables good vegetative growth to be made, whilst on the cessation of the rains, a rise in temperature, and a corresponding drop in humidity, produces the conditions necessary for the maturing of the plant and ripening of the cotton. Dry weather for picking is practically assured, and cotton can therefore be brought in clean and in good condition.

In an area so vast it will be understood that considerable variations of soil exist. Over a considerable part of the region, however, what for want of a better designation is known as "cotton soil" is the predominant type, and most of the cotton at present produced, except possibly in the Mongalla province, is grown on this kind of soil. It is a dark-coloured, heavy soil, containing a large percentage of clay, usually deposited in large flat plains. Under the climatic conditions of the region it produces naturally a large growth of tall coarse grass, the annual burning of which restricts the other species of plants to be found upon it. Considerable areas of mixed forest, or scrub, are found, generally consisting of such trees as can survive the grass fires, which practically clean up the whole countryside each season. There is little in the way of forest clearing necessary, therefore, to enable any extension of cultivation over most of the region.

The different provinces are inhabited by a variety of races and tribes. In the extreme north of the Nuba Mountains and Upper Nile Province Arabs are settled, and mix with the Nubas in the west and with such Nilotic tribes as the Dinkas on the river. The Nubas occupy the greater part of the province bearing their name, while the Upper Nile Province alongside the White Nile, the Bahr el Gebel, Bahr el Zoraf, and Sobat is peopled by Dinkas, Shilluks, Nuers, and other tribes. The Dinkas and Nuers are also found in the Bahr el Ghazal, other important tribes, however, supplying the bulk of the population in this province. Mongalla has its own tribes, some of whom are allied to those living on the other side of the boundary in Uganda.

Generally there is a great variety and diversity of tribes, language, and customs throughout the provinces, and a considerable variation in the cultivating efficiency of the different races. Along the main rivers—where in the past the people have been mainly occupied with fishing, hunting, and the care of their herds, varied with the excitement of raiding, or being raided by, neighbouring tribes—very little cultivation has been carried on. A little dura has been grown, not always sufficient for their own needs, and generally tillage has not been regarded as a fitting occupation for a man. Away from the rivers, however, where a living cannot be so easily obtained, the tribes have had to depend more upon the produce of their fields, and the standard of cultivation, and of effort, is therefore much higher. Over considerable areas, moreover, the presence of "fly" makes the keeping of flocks and herds impossible, so that food crops must be grown, if the people are to eat, to say nothing of drink.

Most tribes in the Sudan are very partial to the native beverage "merissa," a beer brewed from dura, and this taste has an undoubted effect upon the area of grain cultivated. In addition to dura, however, other crops are grown, the most important in different districts being sesame, earthnuts, bananas, and tobacco for local consumption.

From the above very sketchy description of the region and its inhabitants, and particularly when its geographical position is realized, it will be gathered that administration problems of no mean order are involved in securing order and providing peaceful rule. A very general description including most of the races would be that of "naked, pagan savages." Each tribe has its legendary history, some form of religious belief, its own code of morals, and its laws.

To give peaceful government to each, to control the stronger and more warlike, and to protect the weaker, with due regard to their own customs and traditions, has been the task of the Sudan Government in these provinces, which, under the conditions in which the administration took them over, were unable to provide any substantial part of the cost of government. Gradually, however, the administration has established confidence, and reduced the necessity for military occupation, while trade in such commodities as can be produced and exported has brought a certain amount of cash into circulation, and with it some realization by the people of the power of money, at least to supply wants of which they have become aware. But much remains to be done before real progress or any great improvement in the condition of the people can be claimed. Closer administration, involving more expenditure on personnel and transport, is required in most districts; while everywhere medical assistance is an urgent necessity and a greatly appreciated service. The problem of education has scarcely been touched, and its solution, apart from many other difficulties, must entail the expenditure by the Sudan Government of considerable sums of money.

On financial grounds alone, therefore, development of the resources of these provinces is necessary if the responsibility of the administration for the welfare and progress of the people is to be faithfully fulfilled. It is realized, however, that such responsibility entails more even than this, and involves, amongst other things, the provision of opportunities of more permanent and more profitable occupation than has hitherto been available for the people, and the encouragement of those habits of industry and effort without which neither material nor moral advance is possible.

For a good many years experiments and demonstrations in connection with cotton-growing have been carried on at different points in the Southern Provinces. It had been conclusively proved that cotton of good quality could be grown, and that the conditions of soil and climate were generally favourable. Before the war the general level of cotton values, combined with the difficulty and expense of transport throughout the region, was such that the prices which could be offered to the native cultivator were not sufficient to induce him to apply the extra effort necessary to produce even a small quantity of cotton. The general advance of the country, however, and the increased use of money throughout these provinces, combined with the higher run of cotton prices and the development of transport facilities, have changed the situation considerably in recent years. With the much higher prices ruling up to some year and a half ago, it was realized that a price could be offered to the cultivator which should make cotton-growing an attractive side line at least, and still leave a margin between that and the value in Liverpool sufficient to pay for the cost of collection, ginning, and transport.

Elsewhere in the Sudan, and in districts not so favoured as regards rainfall and climate generally, the growing of cotton as a rain crop had proved to be a profitable occupation for the native cultivator.

It was decided, therefore, that a more definite and more sustained effort should be made to extend cotton cultivation throughout the southern provinces, as a means of social and economic development. It was realized to be most important that the confidence of the inhabitants of the different districts in the Government's intentions must be obtained and kept, and that there should be no question of their being exploited commercially. It was therefore decided that the work of extending and popularizing cotton cultivation should be undertaken by the Government through its administrative and technical staffs. It was hoped that a stage of development would be reached in a few years which would allow of all the business side of the development of cotton-growing being left ultimately to private enterprise. As conditions were, however, and in view of the generally scattered nature of the population, and the difficulties of transport, it was realized that for the present only very petty traders could be expected to handle cotton at all, and that their normal rate of profit would require to be such that it would be impossible to secure a fair price to the cultivator. The staff of trained agriculturists was therefore increased, and a certain number were detailed to each of the provinces in question, to assist the administrative officers in

the work of popularizing the new form of industry, and to give such assistance and advice as was required in connection with the technical and commercial side of the work. The Department of Agriculture and Forests undertook the supply of seed, the issue of which to the cultivators was carried out by both administrative and technical officers.

At the beginning a price for all cotton was guaranteed at the time of seed issue, and all cotton taken over at this price was disposed of by the Department. A certain proportion of the crop was shipped to England in order that the fullest information should be obtained as to its value, and the market which existed for the class of cotton produced.

Experiments had shown that cotton of the American type could be most depended upon to give a good yield of fair quality. Egyptian cotton had done quite well in certain districts, but it normally required a longer period of growth than the seasonal rainfall permitted. It was, moreover, found to be more susceptible to, or at least to suffer more damage from, certain insect pests existing in these districts, probably as a result of the longer period required for full maturity. Cotton of the long-staple American type was already being grown in the Sudan, under irrigation in the riverain provinces of the north, and as a rain crop in parts of Kussala, Fung, and the Blue Nile Provinces. This cotton, which is of a very good grade, and with a staple of $1\frac{1}{8}$ to $1\frac{3}{16}$, commanded a ready sale, and it was decided to adopt it as the type to be grown in the Southern Provinces, pending the results of more definite experiments to be initiated, with the object of ascertaining the varieties which would be found to give the best general results under the conditions prevailing.

The bulk of the irrigated cotton of American type in the north is grown under the control and supervision of the Department of Agriculture and Forests, or the Sudan Plantation Syndicate, Ltd. All the cotton is grown from seed supplied by, or approved by, the Department of Agriculture and Forests, and is all ginned in the Government factories, or in those of the Sudan Plantations Syndicate, so that a sufficient and guaranteed supply of seed was available from the start. So far only seed from those irrigated areas, where the crop is grown under careful supervision, has been used in the Southern Provinces, but if the present rate of expansion goes on, it is only a question of time before some further source of supply will be required. It is hoped, however, that as the cultivation extends and improves, areas will be found within the provinces themselves

where it will be possible to raise sufficient seed for some at least of the local requirements.

Since it may appear that the question of the supply of seed occupies undue space in an article of this description, it is necessary to explain that from the very start the Sudan Government has attached the greatest importance to this matter. It is realized that any control of cotton cultivation with the object of maintaining and improving the quality of the cotton produced is difficult, if not indeed impossible, without complete control of the seed supplied for sowing throughout the country. Under the Cotton Ordinance, 1912, the Director of Agriculture and Forests of the Sudan Government has extensive powers in this direction, since no cotton seed may be sown in specified districts unless supplied by or approved by him.

It is not intended in this article to enter into any detailed description of the cultivation of the cotton crop in the Southern Provinces. Admittedly in certain districts the standard of cultivation is not high. The grower contents himself with a rough clearing of the grass and scrub, the sowing of the seed, the minimum of weeding, and the picking of the cotton when it is ready. In other districts very good cultivation indeed is carried on, and with the most primitive of implements. Land is carefully cleared, and kept free from weeds during the growth of the crop, the only implement available in some cases being a sharpened charred stick.

A system of cultivation carried out in certain parts of the Sudan, but not so far extensively practised in these southern provinces, is interesting, and undoubtedly useful where large areas of land carrying a heavy crop of wild grass are available. The system is known as "Harig," or burning, and its success depends upon the skill and knowledge with which it is carried out. An area of grass is carefully preserved from fire at the time when the greater part of the country is being burnt over—*i.e.*, after the rains in each year, and when the grass is dead ripe, and dry. After the early rains have germinated the seeds of grasses and other plants, but before the young growth is too big and succulent, opportunity is taken of temporary dry spells, which always occur, to fire the old grass. Burning readily, as it does, the fire produced is sufficient to destroy the young plants that have started, with the result that there is little or no further growth of grass or other weeds during the season. The cultivator has therefore only to sow the seeds of whatever crop he wishes to raise, and to wait until harvest, being spared the very laborious task of keeping down strong-growing weeds with inefficient tools.

Generally throughout the area there is no tillage of the soil such as is effected in other countries by means of ploughs, hoes, or spades. In a few cases, particularly in Mongalla, previous cultivation is carried out, and in time this will spread to other districts. Demonstrations in ploughing and other tillage operations are being undertaken by the agricultural officers, but at present much of their time is taken up with the distribution of seed and the taking over of the cotton crops.

On one point particular attention has been concentrated, and the importance of the clean picking of cotton is impressed upon cultivators on every possible occasion. Any dirty cotton brought in is refused until thoroughly cleaned, and in a system of rough classification, cotton containing leaf or other extraneous matter is reduced in grade, and paid for accordingly. Under the Cotton Ordinance, it is an offence to offer dirty cotton for sale, and generally throughout the country a high standard is now maintained.

In the districts under discussion propaganda has taken several and varied forms. Generally friendly advice has been the method adopted. The advantages of a readily saleable cash crop have been explained to the people, who have been promised a supply of seed, and assured that a market for their cotton when grown will be provided, and that a fair value will be paid to them in cash.

In some districts, where the payment of the light taxation levied is a source of difficulty to the people, owing to the lack of actual cash, cotton has been taken over at the market value, or guaranteed price, in settlement of taxes. Amongst cattle-owning tribes, who otherwise would have to pay their taxes in cattle, this has been particularly popular. In some of the less settled districts where administration is only really commencing, the cultivation of a certain amount of cotton has been accepted by the administrative officials as a recognition by the tribesmen of their authority, all such cotton being paid for at the rate decided upon for the district. Generally, however, it may be taken that the cash incentive has been the strongest.

The fact that a very little extra labour will produce a bundle or two of cotton, for which the authorities are prepared to pay ready cash, has impressed the native cultivator, and made him anxious to extend his operations in this direction. In those districts in which the people were already settled cultivators the response has in fact been almost embarrassing for the Government. From a region which four years ago produced practically no cotton at all, and very little else that was exportable, a crop of some 4,000 bales of cotton

has been obtained this year, and although seed issue has been limited, the estimates of the coming season's crop are put at from 10,000 to 12,000 bales. As will be imagined, such an expansion has put a severe strain upon existing organizations. Personnel, transport both on local roads and on the river, ginning facilities, have all proved to be insufficient to deal with the output. In most localities the transport season is limited to some four months or so during the dry season, when such roads as exist are possible for wheeled transport or for camels. Distances are great in the Nuba Mountains Province—for instance, the two most promising districts, Talodi and Kadugli, have their centres 100 miles and 160 miles respectively from the river, while Kadugli is a little farther from the nearest point on the railway than it is from the river. The two principal centres in Mongalla are each some 80 or 90 miles from the river. In the Nuba Mountains a certain amount of camel transport can be depended upon in the north, not enough, however, to move the present crop from the Kadugli district alone. Talodi is dependent upon motor transport, and this is also the case of Torit, Yei, and Amadi districts in Mongalla Province.

It will be understood that the transport of seed cotton by motor lorries for distances up to and exceeding 100 miles is not an economic proposition, and the question of local ginneries has had to be faced sooner than was anticipated. During the initial period it was intended that such cotton as was produced in the southern provinces should be ginned at Makwar, where the Government had established a ginnery in 1925, being carried there by river and rail. While a small crop only was being handled on experimental lines this was feasible, but the rapid increase in production has made it impossible for the steamers and barges available to carry all the cotton produced as seed cotton. It is necessary, therefore, not only to increase the fleet of barges, but to reduce the bulk and weight of the consignments, and local ginneries for four of the principal districts have been decided upon, and orders for the necessary plant have been placed in Great Britain. These ginneries are to be erected at those centres most dependent upon motor transport. Talodi and Kadugli in the Nuba Mountains, and Torit and another centre in Mongalla have been decided upon, but whether Yei inland, or a point on the river, shall be selected has not yet been settled.

Enough has been written to give some idea of the task which the Sudan Government has set itself in attempting some development of the Southern Provinces by means of the encouragement of cotton-growing. Although this policy was decided upon when cotton prices

were at a considerably higher level than at present, it is satisfactory to record that even at existing values there is every possibility of cotton being produced in these provinces with a fair return to the cultivator.

It will be apparent, however, that in attempting the solution of the problem of economically administering and developing this region the Sudan Government has found itself faced with a whole crop of minor problems. Such important questions as roads, local transport, erection and operation of ginneries, development of river and railway transport, provision of seed, control of insect pests, handling and financing the crop, to say nothing of the provision of staff, houses, etc., have all had to be faced. Some of these problems have been solved in part or in whole, others still await solution.

It is not possible within the limits of this article, in which technical details have been avoided as far as possible, to discuss all these matters, or to indicate the lines upon which each or any of the problems are likely to be settled. In a further article it is hoped to consider the steps which have been taken to deal with the most pressing difficulties of transport and ginning, and to discuss the arrangements made for the handling and financing of the crop from the fields to the Liverpool Market.

In conclusion, a word of appreciation is necessary of the interest taken in the work and of the assistance so readily given by the Empire Cotton Growing Corporation, the British Cotton Growing Association, and those other individuals and organizations connected with the cotton trade, who have at various times been approached by the departments of the Government and whose encouragement and help have been of the greatest value.

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COTTON IN NYASALAND

BY

C PONSONBY.

Introduction.

Though cotton was growing in Nyasaland in the days of Livingstone, its development as an economic crop, if judged by the test of exports, does not begin till 1902. This is hardly a matter for surprise, since, as I have shown elsewhere,* slave raiding and inter-tribal warfare cannot be said to have been finally exterminated till the late nineties, and for the first ten years of the present century the country was trying to find its feet. The pioneers were experimenting with various crops to find which might be the most remunerative, while it was too much to expect the native, emerging from conditions of barbarism, immediately to develop the desires of civilization to such an extent as to induce him to grow cotton or any other crops with a view to making the necessary money to satisfy those desires. On the contrary—and this applies to a great extent to the present day—as long as the native through the medium of his womenfolk could grow sufficient foodstuffs to stave off hunger and famine and provide beer for his more than occasional beer drinks, he attained the summit of his outlook.

In addition, the tribal system had been destroyed in most parts, so that the British Raj took the place of the chiefs. At first sight this fact may seem to have nothing to do with the growing of cotton, but if comparisons are made with Uganda and Tanganyika it will be seen that the presence or absence of semi-autocratic chiefs does have a very considerable influence on the production or non-production of economic crops.

In Uganda and certainly in parts of Tanganyika the feudal system exists in all its glory. Many of the chiefs, either as owners of the land or in other ways, have direct interests that their tenants (or serfs) should produce as much cotton as possible, and while the tangible results to a chief are evidenced by the purchase of, say, a motor-car and other tokens of advanced civilization, his tribesmen also show their advance in the same direction by the purchase of

* Paper read before the Royal Society of Arts, May, 1926.

Raleigh bicycles, increased costumes for their wives and themselves, and so on. The Government may issue seed and give advice, and the tribesmen may grow the cotton, but it is the chiefs who provide the incentive. There may be ups and downs due to climatic conditions and world prices, but once the native has reached a certain stage of development he will want to continue on the same course, or, to put it more graphically, if he has once owned a Raleigh bicycle he may be lazy for a year or two because the prices are bad and his old tendency to inertia asserts itself, but later on he will want a new bicycle and so be ready to work again—while the influence of the chief will be entirely opposed to a reversion to the ancient habits. A traveller has only to motor through the Eastern Province of Uganda on the excellent native roads (probably the result of the car and bicycle above mentioned) to realize the value of the feudal system.

I heard of one case (in East Africa) where a chief came in great distress to the Provincial Commissioner because he had broken a spring of his new motor-car. The Provincial Commissioner proceeded to the scene of the accident, and pointed out that the trouble was due to a hole in the road, and incidentally that there were other holes all along the road. In a day or two the chief, on his own initiative, turned out 10,000 natives, and the road was perfected.

Such an arrangement works very well, and the natives understand the system and understand their chiefs, but in places where the power of the chiefs has been removed the British Government cannot do those things. No doubt the local Commissioners would like to do them, and with such power the Governor of the Colony or Protectorate could alter the face of the country in a short space of time, but his hands are tied -not by the British Treasury, who above all would like to see those young countries paying their way; not by the officials of the Colonial Office, who are only too anxious to see those countries developed; not by the Colonial Secretary or the Under-Secretary for the Colonies, who visualize a great and prosperous future for East Africa; but by the possibility of questions in Parliament and letters to the English newspapers, often put forward by people who know not the facts and who know not Africa. The attitude adopted by such people seems to be as follows: If a chief turns out 10,000 tribesmen to mend a road for his car, that is the feudal system and perfectly satisfactory; if a Government suggest the compulsory employment of 10,000 natives to help build a railway (for the development of the natives' country), that is slavery and unthinkable.

In Nyasaland, when tribal warfare was finally stopped, the chiefs in most cases were removed, and with them the principal incentive to their tribesmen to work. Consequently, the progress of the country in the last twenty-five years has been mainly due to European pioneers. The following table may be of interest as showing the various landmarks:

Year.	*Imports (Value).* £	*Exports (Value).* £
1901	116,751	21,739
1908 (opening Shire Highlands Railway)	124,687	81,791
1910 (two years after)	193,488	148,150
1915 (opening Central Africa Railway)	216,601	198,006
1916 (one year after)	356,115	289,268
1920	519,949	429,086
1924	564,007	548,156

It should be pointed out that in the period from 1900 to 1910 as mentioned above, the conversion from barbarism to so-called civilization was taking place, planters were trying to find out which crop was the best to grow and how to grow it, and the country was gradually settling down. In 1914 came the war, which disorganized the plantations, upset the native labour supply through the enormous numbers required to act as carriers in the East African campaign, and, in conjunction with the post-war boom, thoroughly unsettled the native. Consequently, any increase in prosperity in Nyasaland has occurred notwithstanding the vicissitudes through which this young country has passed in the last fifteen years, and this fact renders difficult comparisons with other countries (such as Uganda) that have not passed through similar troubles.

Native Cotton-Growing.

Incidentally, the war gave a fictitious value to cotton, and as in those days the native was getting very high prices, he was quick to notice the low prices which followed, and not understanding the vagaries of American fully middling he took the natural course of considering that the white man was trying to sell him piece goods at a high price and to buy cotton at a low price, with the result that he practically stopped growing altogether. As such growing was a voluntary and not compulsory effort on his part, and no chief existed to provide an incentive, the course taken by the native was only what was to be expected. For a year or two everything simmered. The native forgot his grievance, and possibly began again to feel some of the wants of civilization which only money can bring, so the ground was prepared for a fresh start.

The Nyasaland Government could do nothing in the way of guaranteeing a fixed price for cotton, which was the only method of restoring real confidence to the native. This duty fell again to private enterprise, and in 1922 an arrangement was made between the British Cotton Growing Association and the Nyasaland Government by which the former were given the sole right to purchase all seed cotton grown by natives on Crown lands, in consideration of their guaranteeing a price which was to be fixed beforehand with the Government. This arrangement seems to have had the desired effect, and the confidence of the native has been restored because he knows before he plants his cotton what price he may look to receive when the crop is harvested. Under this arrangement, when the crop is sold the Government and the British Cotton Growing Association divide the profits, and as the British Cotton Growing Association have to pay the overhead charges of all their staff and organization in Nyasaland out of their share of the profits, it is obvious that up to now their share in such profits is purely patriotic—in fact, it is common knowledge that so far as the Association is concerned the profits have not materialized, and the Government is not liable to make good any loss which the Association may incur. The share of the Government amounted to £7,259 in 1923 and to £5,576 in 1924. The fall in values since prices were fixed for 1925 makes the position for that year still uncertain, while the prices which were fixed for the present year make a loss in 1926 almost inevitable. The prices fixed for seed cotton have been as follows for first, second, and third grades respectively:

Port Herald District	..	1923-25	2¼d.	1½d.	1d.
" "	..	1926	2d.	1¼d.	¾d.
Up-Country Stations	..	1923	2d.	1½d.	1d.
" "	..	1924-25	2¼d.	1½d.	1d.
" "	..	1926	1¾d.	1¼d.	½d.

At the time the agreement was being negotiated it was suggested very strongly that any profits made should go to form a reserve fund against possible losses in the future, or alternatively, a cotton fund to assist in the development of the natives in cotton districts, but the Treasury insisted that any profits received should go into the general revenues of the Protectorate.

From the point of view of output, the results (probably due in great measure to this cotton-buying agreement) have been satisfactory. In 1922 (before the agreement) the native crop amounted to 387 tons (seed cotton); in 1923 (after the agreement, and a bad year due to excessive moisture and boll-worm), 747 tons; in 1924, 1,864 tons, and in 1925, 2,895 tons. The increase in 1925 was remark-

able, as at one time the excessive rainfall seemed likely to cause a complete crop failure through Red Boll Worm and boll shedding, but the second crop saved the situation.

The native crop (the bulk of which is grown in the Port Herald district at an elevation of about 200 feet above sea-level, and the balance in the Balakas and Fort Johnston districts at elevations of 1,000 to 2,000 feet) now amounts to about 60 per cent. of the total production of Nyasaland.

European Plantations.

As cotton-growing in Nyasaland has in effect been built up by the European plantations, who have borne the burden of nearly all the experimental work, it is interesting to investigate the vicissitudes through which the industry has passed. The following figures are taken from official sources:

Year.	*Cotton Acreage.*	*Exports (Lbs.).*
1902	580	692
1908	8,975	756,120
1912	23,755	3,237,555
1915	29,578	3,065,248
1918	18,141	2,670,834
1921	26,529	1,475,232
1924	20,948	2,182,537
1925	26,120	2,229,317

The above acreage is that of the European estates only. The exports, however, include native as well as European cotton, and consist, almost entirely, of cotton harvested in the previous year.

Exports began about 1902. From that time until 1912 the increase in cultivation was progressive, planting being mainly in the hands of the large companies and also of a number of smaller planters, of whom many were financed by the British Cotton Growing Association, who hoped to foster the industry in this manner. The amounts advanced were considerable, the returns negligible, and indeed it is well known that many loans had to be written off altogether. After the war the Association turned its attention to helping the native industry as mentioned above.

It will be seen from the table that the acreages vary considerably, and have not shown the progressive increase that might have been expected. This is due to three causes: (1) The old acreages may not have been very accurate: (2) one large pioneer company in the Shire Highlands, whose shipments amounted sometimes to 1,000 bales per annum, has now reduced its acreage and is devoting its attention almost entirely to tobacco; (3) under the old system much more

was thought of acreage than of cultivation and rotation, and increased acreage was put in year after year while the old acreage was still being worked out with no attempt at rotation. This may have been due to the high prices prevailing in the war, when certainly large profits were made, but planters were building up trouble for themselves. The land was worked out, the yields became ridiculous, and the abandonment of cotton or the conversion of cotton lands to other uses was the only possible result.

Cotton-growing depends on management and the weather, and as there are, or should be, no secrets between growers, and as the experience of one individual or company may afford a contribution to the general knowledge more accurate than generalizations about all European plantations, of whose arrangements I have not the particulars, I think that the experiences of the British Central Africa Company may be of interest.

This Company commenced planting cotton in very early days. In 1916 it had 8,700 acres under cotton, of which about 5,000 acres were in the Shire Highlands at an elevation of 2,500 to 4,000 feet, and the balance in the lower-lying country near the Shire River at elevations varying from 250 to 1,500 feet. During the war, with high prices and one or two exceptional years, large profits were made, but on many plantations the process to which I have referred above was being carried out. No rotation was attempted. It was cheaper to clear new land, and as long as prices continued good the old land was worked as well. Native methods of cultivation were employed and labour was cheap and fairly efficient.

In 1921 Mr. Sampson was sent by the Empire Cotton Growing Corporation to Nyasaland, and reported on the whole cotton position. His report was not complimentary to the European planter from a farming point of view. Among other matters he pointed out that in his opinion cultivation of cotton at an elevation of over 2,500 or 3,000 feet was a speculative operation.* An examination of the records of our plantations at these altitudes fully justified Mr. Sampson's view. We found that owing to climatic conditions at these altitudes one year in three or four was a bumper year, and had to carry the other years which were from below normal to bad. We then decided to concentrate all our cotton in the Chikwawa district at an elevation of 200 to 300 feet. Here again a great deal had to be done to improve the methods of cultiva-

* Though climatic conditions may be rather different further south in Rhodesia, I venture to suggest that those planting cotton there may wish to consider the question in the light of our experience.

tion and introduce proper crop rotation. The years 1922 and 1923 were to a great extent spade work, but using Mr. Sampson's report as a guide and introducing the procedure suggested by him, the results have very much improved. I went over all the estates with Mr. Sampson in 1921, and visited them again in 1925, and was astonished at the change wrought by the new methods of cultivation. It was also interesting to notice that in the Chikwawa district the natives were altering their traditional modes of planting and cultivation, and copying the new European system.

I asked Mr. Sampson to be good enough to give me his views, and the following extract is taken from a report made by him:

"... As you are aware, I first visited these (cotton plantations) in the cotton season of 1921, when I was reporting on the whole cotton situation in Nyasaland for the Empire Cotton Growing Corporation. I was then very favourably impressed with the soil possibilities of these estates, but felt that the methods of farming and of cultivation could be much improved upon.

"My chief criticisms of the then methods of cultivation and farming are as follows. No attempt was made to conserve the soil moisture at the close of the rainy season. The crop being grown on the ridge rendered this work both difficult and costly. All intercultivation was done with the native hoe, which was very extravagant of labour as well as being inexpeditious. No rotation of crops was ever practised, and cotton was grown on the same land year after year—some of it had been under cotton for several years, and on one or two areas the soil was becoming very light and sandy. This was due to the system of ridging the land then adopted, any rain that fell being washed off the ridge into the furrow and from there following the fall of the land. This has carried off the finer soil particles, leaving the heavier sand behind.

"The Company have for the last three years been closely following my advice, and their whole system of cultivation is changed. A regular system of crop rotation is being introduced, and all these crops, as well as the cotton, are now being grown on the flat, thus enabling implements, adapted from those in use in India, to be introduced for intercultivation and for the conservation of soil moisture. These changes have resulted in a great improvement in the yield and cost of production. In the 1924 season 8,200 acres were under cotton, which gave an average acre yield of 109 lbs. of lint, and this was produced at a cost of 6·55d. per lb. Deducting the above acreage and yield from the totals of European-grown

cotton in that year in the Protectorate, the average acre yield was 59·8 lbs. In a newly opened plantation on the B.C.A. Chikwawa estates, where my ideas of the correct methods of cultivation have been carried out from the commencement, the yield in 1924 was 171·63 lbs. per acre. This compares favourably with the yield obtained in America, where the average for the five years ending 1923 was 147 lbs. The average yield for the whole estates also compares very favourably with that of 1921, which I learn was 72 lbs. per acre produced at a cost of 12·23d. per lb. 1921 was a normal year, and the average yield for European-grown cotton for the Protectorate, after deducting the acreage and crop of these estates, was 58·8 lbs. per acre, or practically the same as in 1924. . . . In 1925 exceptionally heavy rainfall was responsible for a very severe attack of boll-worm, which destroyed the first crop entirely. This was the case throughout the Lower River districts. I visited these plantations in June, and was very pleased with the way the crop was then shaping for a second crop. The plants had all commenced to make second growth, and the prospects were good. The difference between the crops on the B.C.A. plantations and those on other European estates where the crops are still planted on the ridge was very striking. These latter had made very little second growth. The cold weather rains after I left were good, and when I again visited these plantations in September there was evidence of a bumper second crop which was just commencing to break. This fully justifies the methods of cultivation which are now adopted. There is a remarkable difference in the appearance of these estates since I first saw them in 1921. . . ."

The cost of the 1925 crop proved higher than 1924, owing to the fact that the abnormal and incessant rains made it impossible to plant up the whole acreage, with the result that the reduced acreage had to bear the overhead charges. In addition to this, the cost of weeding and cultivation was also higher owing to the wet season. The yield from the second crop was very little under 100 lbs. of lint to the acre, which was not unsatisfactory.

Given a production of, say, 120 lbs. of lint to the acre, it may be fairly estimated that the cost of cotton f.o.r. (which includes ginning, baling, and barging for fifty miles), under existing conditions in this part of Nyasaland in a normal year, should be from 6d. to 8d. per lb. There is every reason to assume that a further increase in yields and reduction in costs may be looked for in the future from the employment of more implements in cultivation, the establishment of

definite rotation crops, and the planting, with the assistance of the Corporation, of more productive strains of cotton.

I would emphasize here that the growing of rotation crops, such as maize and millet, for profit is impossible in this or indeed in any part of Nyasaland until the bridge over the Zambesi is built. A river which is in high flood for three months in the year, and often almost dry for four months in the year, is an insurmountable barrier to the conveyance of low-priced crops, and the whole country looks to the Zambesi bridge not only to provide easier and cheaper transport facilities, but to give it the chance of marketing rotation crops which are vital to the cultivation of its tobacco and cotton.

With an average f.o.r. cost of, say, 7d. per lb., and freight from the country to Liverpool of 1½d. per lb., it follows that the net profit depends entirely on the price. With American fully middling at 1s. in Liverpool and Nyasaland cotton bringing 150 to 200 points on, the profits from a large acreage may be fairly satisfactory. With cotton at lower prices it is a question of working to come out all square and to keep the estates well cleaned against the time when there is an improvement in the price.

What of plantation cotton in the future? It is a difficult question. Some years hence the native may be the chief producer, and the European may concern himself with the handling and export of the crop, but for the present, at any rate, the European plantation, anyhow in some parts of the country, is essential to the industry. For many years to come there will be natives who prefer the certainty of work on plantations to growing for themselves, and for this reason there will be a sufficiency of labour. Later on, those natives may either in communities or as individuals become the growers of the crops for sale to the European ginneries, but at present the improvement of methods of cultivation and the inculcation of such methods into the native mind, together with the establishment of a definite strain of cotton, seem to demand the continuance, even with the possibility of small profit, of the European planter with his energy, initiative, and experience.

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THE PERFECT CONTROL OF COTTON SEED

THE DETERIORATION OF VARIETIES AND ITS PREVENTION

BY

W. LAWRENCE BALLS, Sc.D., F.R.S.

"*Did I ever tell you about a hen Emily we had here . . .? She thought most anything was an egg*"—OWEN WISTER: *The Virginian.*

PERHAPS it is a little late in the day to quote Wister's moral story in an application to cotton, for we appreciate the broad fact that unless we get hold of the right egg we shall hatch the wrong kind of crop. Still there are difficulties in finding the good egg, in making sure that the wise plant knows its own parents, in distinguishing ugly ducklings; and there is certainly a risk that we may count chickens which no possibility ever can hatch for us, any more than "the hen Emily" could succeed with stones, potatoes, or "green Californian peaches."

UNIFORMITY AND THE GROWER'S LIMITS.

Let us begin with the last item. When writing a book about raw cotton in 1914[8] I insisted on the importance of uniformity, as indicated by all practical tradition, and by the shreds of evidence then available from joint studies of growing and spinning. A subsequent decade of direct experiment has made me more cautious in accepting tradition, but it still remains true that the very best cotton is amazingly non-uniform, and capable of great improvement. It would seem that this lack of uniformity is of least importance with respect to the length of the hairs; some elementary facts about the more important and greater variability in "fineness" have been given in an earlier number of this Review.[10] But in 1914 I was so obtuse as to think that nearly all the desirable improvements in uniformity could be obtained by good cultivation of the right kind of pure seed, provided that the pickings were made at sufficiently short intervals to group together those bolls which had ripened under similar weather conditions. Again it is true that much can be done in this way—in fact, it is the most that the grower can do, so far as present learning

will carry him. But it still produces cotton which is very far removed from ideal uniformity.

Such short-interval pickings from pure-line cottons would keep each picking uniform in respect of hereditable differences from plant to plant, and of environmental differences from boll to boll. The accidental differences, together with those due to soil-variations, could be kept fairly small from plant to plant by careful cultivation, but when all was done we should still have left with us the enormous differences from hair to hair on any single seed; they are beyond the cotton-grower's control.

It is worth while to be quite clear about this point, that big differences between hairs on the same seed are inevitable. As the length of the hair is easier to visualize, we shall consider the less important case of length-differences more closely. By using a Sorter[1] to examine the lint from single seeds of many kinds of cotton, we find differences between one kind and another. The statistics for each kind can be depicted in diagrams, and one method of making such diagrams shows the variation of hair-length rather conveniently, in such a way as to resemble the "halo" of hairs which surrounds a combed-out seed. If all the hairs were of the same length, such a diagram would be a circle; the more uneven their length, the more heart-shaped the diagram becomes. The most uniform cotton for length which I have ever met is my pure line, No. 111, offspring of a rogue plant found in Egyptian Assili, and its diagram is not very far from being circular. But although different kinds of cotton thus display characteristic length-diagrams when seed-to-seed variation in maximum length is eliminated by sorting single seeds, still they are usually of similar general type.

Next we can proceed to prepare a diagram showing the average of about a dozen varieties of Sea Island, another for some Indians, thus obtaining composite diagrams, like Galton's composite photographs of families or criminals; we can also make them for Americans, Egyptians, and so on. Now the first impression made by the data obtained with a Sorter is this, that short cottons are very regular, while long cottons are incredibly irregular. But this is fallacious, for if we depict our data in these halo-diagrams, thus avoiding some elaborate calculations which would achieve the same end, we find that the usual heart-shaped form is the same for Indians as for Sea Islands, and for anything in between these extremes.

Thus the average variability of the hair-length on the seed is shown to be broadly similar for all cottons; just as whites and yellows and blacks are all recognisably human. This, in spite of the fact that

some varieties are more or less variable than others, as instanced by No. 111. But there is nothing surprising in this, on second thoughts; we know that all cotton seeds are of similar shape even though some kinds are fatter and some are leaner. Also, the seed hairs are simply a part of the seed, and we may expect that they would also be arranged in a typical form (possibly sometimes related to the seed-form) though this form is disguised because they are crumpled, whereas it would be obvious if they stood out like quills on a porcupine.

We need not labour the detail further. It should be clear that uniformity of "fineness" is still less likely than uniformity of length. Thus, whatever trouble we may take over our cultivation, our picking, our classification, and even over our seed supply, the cotton-grower can never deliver a strictly uniform cotton to the spinner. In the last resort, if the spinner wants uniform cotton, he must make it for himself by fractionating the grower's produce with machinery which is not yet invented. But that is another story[9]. Meanwhile something can be done by seed control. Indeed, when the existing crop is such a mess of different kinds as Bolland has recently described[13] for the state of Ceara in Brazil, seed control is imperative, even in the interests of uniformity.

It should not be assumed that because Ceara is a very bad case, other countries are beyond suspicion. There is no country, except perhaps the little West Indian Islands, where really uniform and pure seed is cultivated. I spent a long while in Egypt over demonstrations of the fact that even there the varieties were mixtures of many kinds; not so blatantly mixed as in Ceara, of course, but quite perceptibly.

ENVIRONMENT REACTING WITH HEREDITY.

Having established the first point, that the improvement of cotton by seed control for uniformity has a limitation which can never be overpassed, we must consider yet another limitation which is apt to be overlooked—namely, the effect of the environment in which the plant is grown. We are too apt to assume that if a supply of good seed has been provided for a country, all will then be well, and to forget that the inherited constitution of the plant reacts to its environment, whether of soil or of climate, in much the same way as the progress of a chemical change reacts to temperature or moisture. Thus there are kinds of plants which bear white flowers in a cool greenhouse, but produce coloured ones in a hothouse. The best seed in the world will, therefore, be no guarantee of a uniform crop of lint, if the soil or weather is patchy; thunderstorms on a clay soil will give a very

dissimilar environment from drought on a gravel soil only a few miles away, and no seed could reasonably be expected to make the best of both such worlds.

Similarly there is no guarantee that the best seed for one country will be good for another country; to change the environment is as radical an operation as to change the seed. The prettiest example is provided by Mesopotamia, where it had been proposed to clean out all existing cotton, import Egyptian Sakel, and grow nothing else. Fortunately I was able to support the man on the spot, without knowing that I was doing so, in his objection to this speciously attractive plan. Captain Thomas was thus enabled to begin by trying every kind of seed he could lay hands upon, whether Indian, Egyptian, or American, in order to find out which kind of cotton was foolish enough to appreciate the climate of Iraq.[18] The result was an easy win for the American variety, Webber 49, a shortish staple which would scarcely have been considered at all under any system of reasoning *a priori* from our present ignorance of cotton. Its success was the more striking because other American varieties of similar type were quite unsuccessful. But not only did Webber give a good yield; it produced lint cotton which was not in the least like Webber, being much longer and finer, not very far behind Egyptian Sakel in its spinning qualities. Thus, by putting an old and well-known variety into a novel environment, which it happened to appreciate, a new lint-cotton has been produced without using new seed. The constitution of Webber was unchanged; it was only the outward and visible form developed in reacting with the new environment that was unusual. The difference was so striking that I advised Captain Thomas to re-name his product by a geographical title, for to have sold it as American Webber would have been to invite low valuations; such is the origin of the new cotton called "Mesowhite," which thus is not new at all in the genetic sense.

Seed supply thus controls only one-half of the complete situation, environment controlling the other half. Perfectly uniform seed will produce an uneven "crop of samples" if the environment is irregular on account of uneven soil or weather. Seed control cannot do everything, and to expect too much from it is merely to emulate "the hen Emily" sitting on peaches.

A Practicable Theory for Seed Controllers.

Thus far we have marked out certain boundaries to the possible achievements of seed control, in so far as that control is intended to make uniform crops in any one season. Let us now enlarge our angle

of view, and consider uniformity from season to season; in other words, the avoidance of deterioration, or "running-out," in our varieties. When we are thus looking for stability from year to year, seed control occupies most of the field of view, and yet it is exactly in this respect that most of the existing control of cotton seed is in part defective.

We will first examine what foundations we can build upon in constructing some workable scheme of ideas about seed control. Such a scheme we must have, for without it all is confusion. If our scheme is to be imperfect, and in our present state of ignorance it must be imperfect—though cotton is one of the best-known crop plants—it will be better to have too rigid a scheme than one which is invertebrate and wobbly. Many folk dislike definite ideas about things which are alive; there is a savour of irreverence in testing animals or plants against mathematical reasoning, so that the slow advance of biological science is punctuated by outbreaks against "hard-and-fast" notions, emanating from such students as Mendel, Darwin, Johannsen, Bateson, Morgan, Willis, and Yule. Nor have all these objections to simplification come from outside biology. Indeed, to the looker-on at both games, there is a strange contrast at present between physical and biological science; the physicist accepts new discoveries, not uncritically, by dozens each year, and works to weave them into his general scheme of things—relativity, quanta, electrons, atomic nuclei, and so forth. The biologist seems to work just as hard to crush any hopeful generalization under the incubus of doubtful exceptions. Still, having to work with cotton, we must have clear notions about it, and the scheme outlined here is one which I have used for the whole of my twenty-one years of research on cotton without finding an unequivocal exception to it.

Our starting-point is the axiom that "like reproduces like." It is partly true, but too swooping; for instance, we have just noted a case where American cotton sown in Iraq did not "produce like," so we must at once amend and restrict the axiom. "Like reproduces like under identical environmental conditions." This restriction covers all considerations of interplay between the individual plant and its surroundings.

But we know very well that, though the environmental conditions are identical, a jackass may be reproduced as an ass or as a mule, according to the method of mating. So our axiom undergoes further restriction, though this is merely for the sake of clearness, since the implication of two parents is inherent in the original axiom. Still, since many Oriental races ignore the Circassian element in their

"pure" pedigree, and since cotton-growers are apt to forget the function of the pollen, we may as well make it definite that "under identical environmental conditions like will reproduce like when in-bred (or close-bred, or self-fertilised)." When out-breeding takes place we have new phenomena to consider; such out-breeding may happen for as much as 5 per cent. of the cotton seeds on any ordinary crop plant. This does not sound serious as a percentage, but it has cost the cotton industry many millions of pounds.

Still, we have to restrict the axiom further yet. The phenomena which Mendel discovered[12] are now general knowledge, and we have all heard that while the blue markings of an "Andalusian" fowl are the outward and visible sign of a hybrid constitution, yet such hybridity only holds good for the body cells, so that when the sex-cells are formed there is segregation into black-carriers and white-carriers. When two of the blue Andalusians are in-bred they may reproduce like if black and white meet in fertilization to renew the hybrid structure, but they are just as likely to produce pure blacks and pure "splashed whites," which thenceforward will breed as true as if there had never been a blue-feathered bearer of a bar sinister in their pedigree. So "under identical environmental conditions, like reproduces like when self-fertilized, provided that the gametic (sex-cell) composition of both parents is homogeneous." If it is not homogeneous, then, sooner or later, like will not reproduce like. If it is, we can speak of the organism as the founder or member of a "pure line."

The Recognition of Pure Lines.

And this brings us to serious practical matters. How can we tell whether the organism studied is gametically pure or not? By the practical test of breeding on from it to very large numbers of descendants; if like reproduces like without exception, we say with confidence that it is in all probability a "pure line" as defined by Johannsen.[17] Which is, I admit, simply arguing in a circle, but it is at present inevitable; gyratory arguments of this kind are almost permissible, and much less demoralizing than fatalistic talk about the "inevitable deterioration of cotton varieties."

The real difficulty about ascertaining whether some cotton really belongs to a pure line or not is simply this: As we multiply it until acres of land are covered, our opportunities for making a mistake in tracing the exact pedigree of every single plant become far too abundant. Forty acres of cotton-field contain about one million plants; for each individual plant in this million we must be absolutely

certain that it grew from a self-fertilized seed off its parent plant. If we are not certain we cannot challenge the claimant to the title of a pure line. We not only must be sure that no plant could have grown from a seed which had been cross-fertilized by bees, but also we must eliminate the risk of foreign seed being brought bodily into the population by careless cleaning of the gins—and once in a million times is not so very careless—or by careless resowing, or by the seed having hidden in the remotest corner of a sack, or by seed-cotton getting caught in a bird's claws, or by seed germinating after a year's delay, or by the sprouting of an old stump, or by mice having hauled seed-cotton round the store-room in order to make their beds. All those accidents have happened within my personal experience, and in spite of all care to the contrary they are so common that Holton and I found about twenty of such outsiders had crept into a twenty-acre field which contained only 7,000 plants. We were able to prove them outsiders, because we had sown the genuine seed in positions defined within an inch, by the use of stretched strings and long graduated guide rods. Thus the onus of proof about pure lines is reversed; it is almost impossible to prove in the field that a pure line of cotton seed, certified as such by the cotton-breeder's genetic laboratory technique, is not what it claims to be. It is far more likely that the farmer should be wrong, for no genetic research could tolerate errors of 20 in 7,000, more than one-tenth per cent.

Supposing that we may take the word of the precisian in the laboratory that, to all human likelihood and in the absence of fuller future knowledge, some kind of cotton is a pure line, wherefrom like will reproduce like, and that for the moment we can postpone any discussion of the way in which such pure lines are obtained and maintained. Are there any further exceptions to our axiom? We can restate it now more concisely: "When replaced in the same environmental conditions all the true descendants of a pure line will exactly resemble their pure-line ancestors." If there are no exceptions, here is the means for creating a perfect seed control system, proof against "deterioration," that bugbear of the cotton-grower.

MUTATION.

The answer to the question in the last paragraph is that one real exception is believed to exist, but also to be so rare as to be no practical deterrent. It is so rare that we hardly know anything about it, and is termed a "mutation." But there are many ostensible exceptions, easily confused with real mutations, and these

latter are responsible for most of the confusion in our ideas about seed supply.

First let us attempt to define a real mutation. The name was introduced by De Vries,[11] who produced experimental evidence which turned out in the long run to be erroneous. It is one of the interesting episodes in the history of science that he should have reached a conclusion correctly on wrong premises. Previous students of evolution had mainly inclined to believe that the organism changed imperceptibly in successive generations; that it was plastic, so to speak, moulded by its surroundings, and passing on to its descendants something of the new characteristics thus acquired. While Darwin eventually adopted this as the less difficult interpretation, the early statistical work of Bateson[11] had shown clearly that variation was not thus smooth and continuous, but jumpy. Then the rediscovery of Mendel's law showed the same kind of discontinuity to be characteristic of the sex-cells, though the general appearance of the final result, in all but the simplest cases of heredity, was so nice and smooth as in no way to suggest the sharp discontinuities from which it had been built, any more than the curve of a brick arch suggests the rectangularity of its component bricks.

Thus a pure line might continue to reproduce for many generations, like from like, until some day and somewhere, something slipped out of position in the mechanism of sex-cell formation—a sort of accidental gear-change—and an offspring unlike its parents appeared. This was De Vries' conception. Whether the new form survived or not would depend on natural selection, as recognized by Darwin, following Malthus, and on pure luck. In the very beginning the last would be an important factor. Also, some mutations might be imperfect monstrosities, and so non-viable; we are only concerned with the surviving viable mutations. On Willis's view[20] the rest of the story under natural conditions is only a question of time on the average; the new species or new genus or new order will increase and spread as far over the earth as its constitution and environment will allow it to go. This general evolutionary aspect would be rather beyond our present scope if it were not the case that Yule,[21] working with Willis, has treated the problem mathematically and reached the astoundingly simple conclusion that the whole complexity of orders, genera, and species which makes up the flowering plants of the world could have been built up in the time available if a viable mutation had happened once in every ten to sixty years. Thus the chance of a pure-line pedigree being disturbed by mutation in any one genus, such as cotton, is—on the average expectation—quite

negligible. It would seem, therefore, that we may wash out true mutation altogether from our list of possible troubles in cotton-seed control.

It might, of course, be the case that particular genera pass through periods of intense mutational activity, as De Vries at first thought his Evening Primroses were doing. So cotton might also be in a mutational phase, but to assume that our petty interest in cotton should coincide with such a rarity in the millions of years during which the genus has existed is mere egotism. It is much more likely that we are making experimental errors of 20 in 7,000, such as I have mentioned.

There is also some evidence that mutation may be induced artificially, though it is not easy to be clear whether the treatment has induced the actual mutation or has developed a pre-existing one. If it can be done under control, so much the better for economic biology in general. Meanwhile we are safer in adopting the view that the genesis of a new mutation under natural conditions is spontaneous, like Topsy, in which case the origin of new species has a certain inverse analogy to the process of radio-active disintegration, being quite uncontrollable.

Imitation Mutation.

If we may trust the pure-line pedigree for all practical purposes, as I did for years before the welcome results of Willis and Yule's co-operation fitted in with my intensive experience of a single genus, is any other episode likely to happen in such a pedigree which simulates a real mutation? Certainly, there are many. Any contamination by natural crossing or by admixture of seed in dozens of possible ways (whereof I have already mentioned a few) will cause a " rogue " plant to appear in the pure-line field. Now it must be confessed with sorrow that all students of cotton do not seem to feel the necessity for clear-cut notions; let me cite a distinguished one whom I met some fifteen years ago. He also had been writing papers about heredity in cotton, from which it seemed that mutated cotton " grew like asparagus in May " over in his country. So I tried to get at his definition, and at last I found that if he saw a plant in an ordinary field of an ordinary commercial variety, and if that plant looked very unlike any of the others, he called it a mutation. Which is quite an easy thing to do!

The only cases known to me in which there is a faint likelihood of true mutation having been witnessed in cotton are, firstly, the case described by Harland, and secondly the occurrence of a single plant

with truly variegated leaves out of some 50,000 then grown from my strain No. 77. The second is an extremely crude case, if genuine. The experimental errors operating against any clean proof of mutation in cotton are enormous.

If, however, we discard loose terminology and prune down experimental errors, there is still a class of straightforward heredity phenomena which simulate mutation superficially. A common and simple example turned up when I crossed together two cottons, both naked-seeded, and found that the first-generation hybrid had a seed completely covered with fuzz, like an American. In the next generation approximately one plant in sixteen had naked seed, yet both parents bred true to nakedness. Without undue detail, this was an example of a case well known in the post-Mendelian days, where the nakedness of either parent was due to the loss of a distinct "factor." When the two lost factors met again in the hybrid, full fuzz reappeared; it looked like a mutation, had it not been known to be a cross. So in more complex cases it is possible that our "pure line" may not be really pure, but that some buried factor in its constitution can only reappear on the surface in one particular mating of the sex-cells out of many thousands. The science of genetics knows many such cases, of every degree of complexity and rarity, so that in the extremely rare and complex cases their separation from a true mutation is experimentally not easy; De Vries' work is a case in point. Still, we need not let them deflect us from an attempt to provide a rational and durable basis for cotton-seed control.

The Plant-Breeding Laboratory.

Thus far we have confined ourselves to considering how far and for what reasons we may hope to secure uniformity in our cotton crop, and to maintain it uniform from year to year. The question of inheritance has only been touched incidentally, and for my present purpose sufficiently. A very few of us have made serious though small contributions to scientific knowledge of cross-breeding phenomena in cotton; in the main, we are ignorant. Till that ignorance has been rectified by many years of disinterested and unprejudiced genetic studies at the new Cotton Research Station in Trinidad, any discussion is full of risks. Moreover, for some years to come there will be quite enough work for the economic cotton-breeder to do in the mere isolation and purification of types from the existing commercial mixtures. Even for this work some knowledge of heredity is needed, but most of the work can be done slowly by skilled rule-of-thumb and especially by the use of statistical observation. Thus,

for the present, Johannsen's conception of the pure line is practically more important to cotton-growers than Mendel's far greater discovery.

There is plenty of material available from which to prepare hundreds of distinct pure-line cottons, without any deliberate hybridization at all. The small percentage of natural crossing which takes place in the field has been quite sufficient to keep the population well mixed, and the breeder's present task is simply to self-fertilize each plant he isolates, until some family of its progeny ceases to show any constitutional heterogeneity. This sounds quite simple, but it implies a deal of work. Until we have real knowledge of the "useless" side of cotton genetics, there are no short cuts to this end.

In spite of the elementary fact that every subsequent operation in practical seed control must be pivoted on the laboratory, we need not here consider it further. Its work affects us by providing pure lines of seed, and in keeping them from contamination by methods of precision impracticable in the field.

Ancillary to this work is the testing of agricultural and spinning properties. Then comes the propagation of these nucleus stocks into bulk, and their distribution to the grower. The actual distribution is rather administrative than technical in its scope, and need not be discussed at present, though it might be observed in passing that we have been apt to put the cart before the horse. In other words, through lack of knowledge it has been necessary to organize seed-distribution before making sure that the same seed would be available for distribution in the future. But as nobody used to believe that any cotton variety could be permanent, this inherent weakness was not obvious.

Seed Renewal.

We have now to deal with a fact of fundamental practical importance, upon which any and every seed-control system must pivot itself if permanent success is desired. That pivotal fact is the inevitability of "seed renewal." This renewal should not be confused with "change of seed"; the latter is necessary for crops like potatoes, which are not propagated by seed at all; it is sometimes advisable with true seed crops, in order to counter the effects of natural selection, acting on an impure variety. With pure lines there can be no such effects to necessitate change of seed, but there is an imperative need for seed renewal, in order to compensate for unavoidable contamination of the pure line.

I have called attention in previous paragraphs to the need for applying every precaution available in the genetics laboratory to

ensure the maintenance of a pure line. Concurrently it has been noted that such precautions are so difficult to apply under field conditions (with the absolute certainty required) that a few "rogue plants" are bound to find their way into the population after a year or two, even with all practicable care. Unless, of course, we have an island all to ourselves, one island to each pure line; such conditions exist only in the West Indies, and even there it is probable that there are stray plants outside the pure line. The source of this contamination we have found partly in the bodily admixture of seed happening rather more easily than one would expect; partly in the carriage of foreign pollen to the crop by bees, thereby making natural hybrids in the next generation.

—Now it might be argued, as, indeed, it usually is argued, that a little contamination of the pure line does not spoil the crop. Nor will it so far as the immediate crop is concerned; even 10 per cent. of rogues might not catch the spinner's notice. But the student of genetics works entirely in the future, and in this instance his concern is not with the present degree of contamination, but with the after-effects thereof. Those after-effects are cumulative, gathering size and momentum like a rolling snowball, year by year. The admission of one single rogue plant into a pure-line cotton population, even of millions of plants, must eventually contaminate the whole population inevitably. The rate of building of further rogues from the first one is slow at first, then more rapid, until by the time that the population contains 5 per cent. of such rogues we need not expect it to last more than a couple of years longer as a recognizable kind of cotton. This is the condition in which so many new commercial varieties are put on the market, and this is why the records of cotton-growing are littered with the names of extinct ephemeral varieties.

The reason for this acceleration of contamination is quite straightforward. A parallel case to which my attention was recently drawn in the Lea Valley will serve to illustrate it. The would-be possessor of a fine stock of tomatoes chooses the best plant and grows on from its seed. Hence irregular crops are produced, because these superlative plants are usually such because they are first-generation hybrids, which "split up" in the next generation. For reasons which are not clearly understood, though some hints have already been gathered from cotton hybrids, such crosses between reasonably similar pure lines are much more vigorous and prolific than the pure lines themselves. Taking some crude figures at random from my note-books I find that when pure lines Nos. 77 and 310 were growing side by side with the first-generation hybrid between these two Egyptian varieties, the

number of bolls produced per plant was roughly thirty on No. 310, forty-five on No. 77, and sixty on the first cross. Exact comparisons are, of course, impossible without the use of chequer-board plots, but the figures are of the right order. In the cultivation of maize we never see a pure line, outside the genetics laboratory; it is an insignificant, grassy kind of plant, but the crossing of two such weeds at once produces the massive maize plant of common acquaintance.

So, when a rogue plant finds its way into a pure-line population of cotton, whether as a seed or as a pollen grain, its hybrid offspring will usually be more prolific than those of the pure-line. Then we have a good example of natural selection to watch. year by year; for it is self-evident that as the infestation by natural crossing spreads through the crop from the descendants of the original rogue, so its rate of spread will be further accelerated by the increased seed production of the hybrids. Some rough experimental data from small plots of only a hundred plants showed that successive years could give such figures as a $\frac{1}{2}$, 4 and 30 per cent. for the amount of contamination. Thus a pure line once contaminated has only a few years of usefulness to expect.

A digression is advisable at this point. The reader may reasonably ask why the low-yielding pure line should be grown at all, seeing that we need high yield from our cotton fields. The answer is found in the analysis of yield, which separates yield per plant from yield per area, and shows that the admitted inferiority of the pure line in yield per plant can be balanced at once by a slightly closer spacing of the crop, giving more plants per acre. The inferior yield of pure-line plants is not very striking in the case of cotton, and it can thus be compensated easily. The deliberate cultivation of first-generation hybrids between American and Sea Island, which are tremendously prolific as individual plants, was actually effected in the West Indies by Thornton.

Natural crossing, natural selection, and natural mistakes in handling the crop thus make our cherished pure line a mere ephemeral possession if we put it to use in field cultivation. Yet it is still the only kind of seed worth controlling, for all this natural wastage of our pure stock can be countered if we continually renew the spoilt seed. In fact, such renewal has now been recognized as being desirable even when using semi-pure stocks which are being kept to a level standard every year by skilled rogueing, such as Domains Sakel. With absolutely pure lines there is no difficulty about preparing a few thousand dependable seeds each year, either by the usual precautions of the genetic laboratory, or at less total cost, though with more

investment of capital, by the use of bee-proof cages. From such large handfuls of perfectly pure seed whole provinces can be planted in a very few years when the propagation is gone about in the right manner.[5] If such propagation is repeated annually as a matter of routine, then as the older seed becomes appreciably contaminated, it is condemned to be crushed entirely for oil, and newer stock comes up automatically to replace it and to be replaced in its turn.

It can hardly be too strongly emphasized that no permanent solution of the seed-control problem for cotton can be attained without regular and automatic seed-renewal. Unless, perhaps, when someone succeeds where I failed in 1908,[7] and gives us cottons which do not suffer from natural crossing at all.

The Stubbornness of Pure Lines.

Even so, there is little use in supplying seed unless that seed will remain true to type over an indefinitely large number of years or until we wish to change it. Such permanent usefulness can only be obtained in two ways: either by roguoing to an unchanged though indefinable standard, as in Domains Sakel, or by using pure lines. The disadvantage of the former method is that it demands an immortal body for the person in charge of the roguing, otherwise the standard risks a change with each change of the man in charge. The pure-line method is automatic and impersonal.

Pure-line cotton seed, with continuous renewal, thus gives a permanent, automatic, and non-subjective system. This is worth consideration, and it has other advantages, being proof against deterioration or acclimatization—which are the plus and minus of the same thing—for the pure line is not plastic under natural selection; there are no constitutional differences to be selected. It is quite true that selection work has been done on stocks derived from pure lines, but such selection has not been made from the pure line itself, but from rogues found in the contaminated population. As it is quite likely that No. 310 will presently become well-known enough to be quoted erroneously as an example of a pure-line cotton which will show deterioration in the future, some confusion for later students of cotton may be avoided if I here disclaim half the credit I have been given so kindly for its genesis, and at the same time illustrate my thesis. The facts of the case are as follows:

A bag of seed cotton from an ephemeral variety called Sultani was given me in Egypt during 1907 by Mr. E. A. Benachi. Locks of this seed cotton were examined as representing individual plants, and seed

from some of the longest locks was sown under the new-strain reference numbers 300 to 318. Only two plants survived from lock 310; both gave lint like the parent lock, but the branching habit of the two was markedly dissimilar. The less-branched one was self-fertilized, and from 1909 onwards a family of this was grown yearly. A detailed statistical study of fifty such plants was made in 1911, and no sign of heterogeneity could be detected in any character. In this year some natural seed was used in some tiny experimental plots and showed this pure line No. 310 to be a low-yielder, shedding its flowers far too easily for the climate of Giza. In 1912 I decided to include it in our new project of pure-line propagation, but as a mere side-show, simply to demonstrate that Egypt could grow really fine cotton to replace the collapse then impending of ordinary Georgias and Floridas under the impact of the boll-weevil. A rough gauze bee-proof cage was built over a plot of fifty plants. The duplicate plot to this one was left unprotected against natural crossing from the brown cottons around; the seed from this gave a crop in 1913 which was barely recognizable for its nominal parentage; no less than 15 per cent. of brownish locks contrasted strongly with the white of the residual pure line.

The caged seed was grown at Korashia in 1913 by the State Domains, wide sown and partly protected by a " belt " of close-sown cotton from this naturally fertilized seed, which latter stock had been carefully rogued previously for this purpose only. The former produced a small stock of 60 kilogrammes of seed, not seriously contaminated, but not strictly pure. In the same year it was grown in the extreme northern delta at Neguileh, through the kindness of Haddad Bey, in " observation rows " as a field crop on light salty land, watered very frequently; in this milder climate it cropped better, shed less, and was judged by the late M. Marco Nacamuli, to have produced " the finest cotton ever grown in Egypt " during his forty years' experience.

When I left Egypt the stock of 60 kilos was taken over voluntarily by Mr. Jefferys, of the Domains, the cotton having been officially condemned as too long and fine for Egypt. Many years later, when I grew some plants from laboratory stock at Bollington in 1925, its characteristics were unchanged, as were those of its companion, No. 77, which is now twenty years old. I had known all along that it was a tricky cropper, thereby balancing its excellent spinning-tests. Mr. Jefferys set himself to improve its yield by selection from rogue plants found in it. That he had ample material was evident by mere inspection of the seed cotton which he sent to England from the 1915

crop, only two generations removed from practical purity, after careful cultivation in field crop, but exposed in small plots to the ordinary risks of natural crossing; fully 10 per cent. of the cotton was brown. By picking from those plants which did not shed easily and yet had the typical lint, he slowly converted the contaminated mixture into a fairly homogeneous variety which produces lint not much inferior to my genuine No. 310, and is also a practicable field crop with a good yield. Thus the modern " Domains 310 " is as much his child as mine. It only remains for someone to extract a new pure line from his variety, when this useful cotton can be preserved in perpetuity.

Pure lines once isolated are good for all likely time. They are not plastic, like mixed varieties. If they do not like an environment it is useless to wait year by year for them to acclimatize themselves. Better try again with other pure lines. Herein is one possible disadvantage, seeing that no country is uniform in its soil and weather; an impure variety may possibly put up a better performance on the average of many different places, through the flourishing growth of one or other component in the mixture.[10] It may be so for cotton, but we have not enough evidence to be sure. The degree of elaboration to which it is worth while developing a seed-control system by continuous renewal of pure lines can only be ascertained by actual trial. For example, it is not inconceivable that a deliberate mixture of two pure lines might be the best supply for some districts, such, for example, as some parts of Africa where the rains are very erratic in their timing; such mixture would be quite practicable under a seed-renewal system, if made from pure lines giving similar lint. In any event, it is certain that the phenomena of "adaptation" to local peculiarities of the environment are much more emphatic with pure lines than with mixed varieties.

Propagation of the Nucleus Stocks.

We come now to the actual procedure whereby the nucleus stock of a pure line can be propagated, so that each year sees a few tons of undeniably pure seed sent off on its career of expansion from the laboratory centre. In this process the supremely important factor is the speed of such propagation, for the reason already given, to wit, the utter impossibility of preventing contamination in each year after the seed has left the bee-proof cages of the laboratory. The significance of rapid propagation in reducing such contamination is twofold; firstly, by the mere reduction of opportunity, each year's

handling representing one such opportunity. Secondly, by reducing the "perimeter error" from natural crossing, which term is a concise description of the fact that plants on the edge of a plot are more likely to receive foreign pollen from visiting bees than are those in the centre. The larger the plot, the smaller is the percentage of its population contained in a marginal zone of any given width. In a square plot of a hundred acres or so it is probably true that the central five acres is as well protected from foreign pollen as if it were inside a bee-proof cage; it could thus be used itself as the nucleus for sowing the same area next year, so reducing the area of caging required in the laboratory. The centre of a one-acre plot is, conversely, hardly protected at all, the perimeter risk extending over practically the whole area. Thus there is every practical advantage in leaping forward through the first two years of propagation, which can be done at an astonishing rate if care be taken to use to lowest possible seed-rate concurrently with the highest practicable seed-production per plant. I have formerly described in this Review my procedure for the former purpose by the "sand-sowing method,"[6] while the effect of crop-spacing as the sole controller of the latter has been rather fully analyzed elsewhere.[3] It will suffice to repeat here some figures which show the cumulative effect of such measures (see Table), while a photograph of the seed cotton described by the figures in the fifth column of this table will serve to make them tangible. The sixth column presents a conservative estimate of the rates of propagation practically obtainable in a seed-renewal system, and are perhaps worth examining.

In routine work the "first year" of the table would be imaginary, as a reserve stock of more than 1,300 seeds would always be available. Thus, the first operation of routine would be to raise a thousand plants wide-sown in a cage, one-fifth of an acre in area. From this caged seed a block of some seventy acres would be planted with ordinary field spacing of about 10,000 holes per acre, but sand-sowing to raise only one plant per hole. A protecting belt grown from seed of the previous year might usefully surround the area to the depth of a few yards. The sixteen tons of seed harvested from this area would be freshly available every year, and would yearly pass out to landowners of good repute as in current seed-supply practice.

It will be observed that by following out the logical implications in full, instead of half-heartedly, we can provide our seed for relatively small expenditure, namely, the capital and upkeep cost of a one-fifth acre cage, which is cheaper than bagging flowers by hand, the extra labour, approximately double, required for sand-sowing seventy

acres; lastly, a slight reduction of normal crop on this area through using single instead of double plants.

The seed thus obtained is nearly impeccable, and will cover 600 acres in the fields of the selected landowners, or on a proper seed-farm. Ten times this area is a reasonable estimate for the next year on ordinary land, by which time it may be expected to show a small proportion of rogues, leaving it quite good enough for 50,000 acres the year after, and ready for crushing off half a million acres in the last year of its life.

Lest these statements should sound too much like mere juggling with figures, it is advisable to repeat that they are conservative estimates, understating the results practically obtained on a moderately large scale in the past. It is, however, more important to emphasize that with such a system the varieties can be changed as the market demands them, the same identical cottons can be produced without deterioration over an indefinite period, and none need ever be lost. Thus I have heard regrets expressed on many occasions that the old nep-free Yannovitch cotton is extinct; a handful of pure-line Yannovitch preserved in cool storage could have been run up into sufficient bulk in three years through such a system to test whether these regrets were sufficient to pay for its low ginning out-turn.

We need information as to the best way of storing cotton seed, but it is probable that desiccated seed sealed in air-tight containers could be stored at temperatures a little above freezing-point for fully fifty years. I have had good germination from seed half this age kept loose in London. Nucleus stocks of 10,000 separate pure lines could be card-indexed and filed in one small room, a thousand seeds of each. Any cotton-breeder would then have the satisfaction of knowing that his work was not wasted, even if it was not immediately usable, and every possible kind of cotton would eventually be available in such a file.

In the preliminary trial of rapid propagation which I carried out for the Egyptian Government in 1912-13,[2] we were hampered by extemporization, while the propriety of sacrificing land under wide sowing was much argued (see Table, col. 4, third year). The use of adequate areas of caging enables this to be avoided (col. 6), but the immense influence of wide sowing must not be overlooked where land is cheap. The equal importance of growing a separate plant from every possible seed is more obvious.

Testing.

The technique of testing new pure lines for their yield and for their intrinsic spinning value is an essential part of pure-line seed control, but need not be elaborated in this article. The general principles of the former have been most clearly enunciated by Yule and Engledow[22] in the last two issues of this Review, while the use of "plant-development records," for cotton, whereby the intangible "probable error" of the plots is transformed to a visible and informative part of the yield-trial, is probably familiar enough to cotton workers [3, 15]. The technique and significance of spinning tests have been described elsewhere, and the new reports of the Technological side from the Indian Central Cotton Committee[10] will show how such tests may be conducted with admirable thoroughness.

Conclusion.

The text of this article is based upon the unpublished manuscript of an account which I wrote in order to preserve an orderly record, at the conclusion of my Egyptian service, when all the minute and intricate details of our trial of the method were freshly available. This revival of the subject after the lapse of a dozen years is due to my belief that our system was somewhat in advance of its time. Moreover, the researches of many others joined to my own during the past decade seem to have given at last a fairly complete story of the way in which the "properties of raw cotton" become responsible for the properties of yarn made therefrom. By the courtesy of the Fine Cotton Spinners, with whom I have lately been associated, permission has been given for early publication of the main argument of my conclusions on this matter, and the availability of this new knowledge will necessarily make the work of the cotton-breeder much less vague. Such increased exactitude in the prescription of demands for raw material will call for similar exactitude in its provision, and in the preservation of varieties without "depreciation" from year to year. For both requirements the pure line alone is finally competent.

I was much impressed—perhaps I should say depressed—when I started a garden in England in 1914 to find how very far the seed of vegetables and flowers from our best seed-merchants falls behind the standard of pureness which we had attained with Egyptian cotton. Not till then had I realised how high a standard for commercial use we had set and reached. The pure line gives an impersonal exactitude

which no approximate methods such as rogueing, mass-selection, or ordinary selection can possibly provide, whatever may be their temporary convenience. To the best of our present knowledge a pure line is nearly immortal.

EXAMPLES OF PROPAGATION RATES WITH COTTON SEED.

(1)	(2) *All Egypt.*	(3) *Special Crops.*	(4) *No. 111.*	(5) *No. 77.*	(6)
	Actual Examples with Egyptian Cotton.				*Estimate.*
First Year:					
Seeds sown ..	20	8	1		1
Plants grown ..	2	2	1	—	1
Seeds per plant ..	100	300	400		1,300
Seeds harvested ..	200	600	400		1,300
Second Year:					
Seeds sown ..	200	600	200		1,300
Plants grown ..	20	150	50	—	1,000
Seeds per plant ..	100	300	600		1,300
Seeds harvested ..	2,000	45,000	30,000		1,300,000
Third Year:					
Seeds sown ..	2,000	45,000	30,000	8,000	1,300,000
Plants grown ..	200	11,000	10,000	5,000	800,000
Seeds per plant ..	100	300	1,000	2,000	200
Seeds harvested ..	20,000	3,300,000	10,000,000	10,000,000	160,000,000
Crop expressed as a power of the annual rate	10^3	61^3	316^3	$1,250^1$	400^3

NOTES.

Col. 2.—All Egypt, based on commercial statistics.

Col. 3.—Exceptionally good field crop, grown with special care on best land; figures largely hypothetical in the sense of being composite.

Col. 4.—A rogue selected in the first year, propagated and purified simultaneously. Second year grown in small bee-proof cage. Third year in wide-sown field, with belting.

Col. 5.—This records only the emergency work on this pure line in 1913, when nearly all the sown seed was destroyed by mole crickets, leading to the devising of sand-sowing in order to use the whole of the "emergency reserve" of seed. Roughly equivalent to producing a ton of seed from ten seeds grown in the previous year.

Col. 6.—Wide-sown in large cage in second year. Field crop at normal spacing in third year, sand-sown as single plants, not as pairs.

APII EE P II

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SOME NOTES ON THE RED (SUDAN) BOLLWORM (DIPAROPSIS CASTANEA Hampson) IN NYASALAND

BY

C. B. R. KING, M.A.

I.—Introduction

Name and Distribution.—*Diparopsis castanea* Hamps. has long been known in Nyasaland as the "Red Bollworm." In other parts of Africa it is generally referred to as the "Sudan Bollworm." Its present distribution appears to be as follows: Nigeria, French West Africa, Anglo-Egyptian Sudan, North-East Rhodesia, Nyasaland, Mozambique, and in most parts of South Africa. It also occurs round the north-westerly margin of Lake Nyasa in Tanganyika territory, which geographically belongs to the cotton-growing areas in the north of Nyasaland. It was reported in 1925 as not occurring in Uganda, North-Western Rhodesia, or in Tanganyika territory (excepting the Lake Nyasa littoral mentioned above).

Historical.—It is difficult to find out how long this pest has been serious, as definite records of it only begin in 1911, the year in which the first entomologist, Mr. E. Ballard, was appointed to the Protectorate. There is no reason to think, however, that the pest in the early years of cotton-growing was more or less absent, as some old inhabitants would lead one to believe. It is likely, however, that from the late nineties down to 1913, during which period the acreage under cotton increased greatly year by year up to 26,000 acres, the spread of the Red Bollworm lagged until the area under cotton became more or less stationary. At any rate, the average weight of lint per acre in those years, although as a rule higher than at present, was only above 100 pounds in one year.* The report for 1908 states that there were only "small returns per acre." The year following, the yield was 81 pounds of lint per acre, and in 1910, 103 pounds. In the latter year "Bollworm" was reported bad. The years 1905 to 1912 averaged 68 pounds of lint per acre, the highest return being 103 pounds and the lowest 45 pounds. The next four years, 1913 to 1916, saw an improvement, the figures being 85·8, 95·2, 130·8, and 101 pounds respectively. In the first year of this period there was a heavy attack of *D. castanea* in most districts, and the following year it was reported as being the most serious cotton pest. The yields since 1917 up to the present time have been lower again, ranging from 85 to 75 pounds of lint per acre. It seems

* All figures are for European-grown cotton.

probable that damage from insects has always been considerable, though not specifically noted until the arrival of an entomologist. Such damage is not always due to bollworm, as in certain years stainer-borne internal bollrot has been very severe.

The present situation with regard to bollworm is, without doubt, chiefly due to the insect adapting itself entirely to cotton, where cotton is grown year after year on the same land. Cotton planted on new land, some miles from the nearest cotton field, is usually more lightly infested the first year.

Planting Times, etc.—The time for planting cotton depends upon the altitude. In the Shiré Highlands cotton is usually sown in December, but on the lower levels, including the Shiré River districts, it is not sown till January or later. At all events, the sowing corresponds with the first planting rains. Flowering begins nine or ten weeks after sowing, and the first bolls open in April or May, in which months the rains usually stop, and the dry, cool season commences. The majority of planters get a second crop, which matures in September and October. It is the first crop which suffers so heavily from pests, so much so that in bad seasons there is nothing to pick. The second picking, which yields the bulk of the crop, comes after a long, dry spell, and is mostly first grade; although a spell of cold, rainy weather, lasting three or four days in the dry season, will bring on a further mild attack of bollworm.

The following paragraphs give a description* of the different stages for recognition in the field, and some notes on the life history and habits of *D. castanea*.

An Appendix gives a list of pests recorded in the Protectorate.

II.—Description.

The Egg.—The eggs of the Red Bollworm have the shape of a Jaffa orange, with a diameter of 0·6 mm. The colour of a freshly laid egg is sky blue. The external wall is ribbed and reticulate, with short chitinous processes, slightly hooked at the tips, on the ribs, directed upwards (*v.* Plate, Fig. 4).

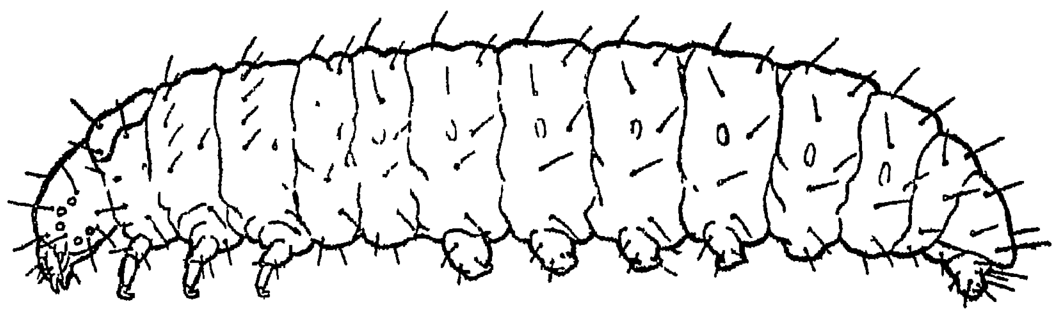
The Larva.—The first-stage larva has a black head and black thoracic and anal plates. The rest of the body is a pale cream with slightly darkened patches about the insertions of the setæ. In length it is about 2 mm.

The second instar shows rose-coloured markings on each segment, shaped dorsally like a broad arrow with the point cut off. The head and the thoracic and anal plates are still black.

* For a detailed, systematic description, the reader is referred to Hampson, *Catalogue of the Lepidoptera Phalænæ*, vol. vii., p. 509.

The third instar exhibits the same red markings as before, which are so characteristic of this caterpillar. The head and plates are chestnut in colour.

In the last stage the markings are somewhat fused together at first, and as it approaches its fully fed condition, the trilinear dorsal marking disappears, giving place to a transverse red flush on each segment, on a green or creamy ground. The head and thoracic plates are chestnut, but the anal plate has turned whitish, with a longitudinal dark patch in the middle, dividing the plate into three more or less equal parts (*v.* Plate, Fig. 7).



PLAN OF SETAE OF RED (SUDAN) BOLLWORM (4TH INSTAR).

The Pupa.—On the completion of the period of growth, the larva descends to the ground, in which it constructs an earthen cell in a manner to be described later. The pupa is of a light chestnut colour, and measures about 15 mm. in length (*v.* Plate, Figs. 5 and 6).

The Adult.—Once the observer has seen the moth he will have no difficulty in recognizing it again. The preponderating colour is a brick pink, but there is a considerable range of colouring varying from a deep mauve to gold, and more rarely straw. These pale forms, seen in either sex, occur in some 5 per cent. of moths. In the humeral angle of the forewing is a small chocolate-coloured triangular patch, and near to the distal edge of the wing, and parallel to it, is a bar of the same, but paler, colour, often tinged with olive. In the paler forms these marks are of correspondingly lighter colours. These two markings, together with the general coloration, will show unmistakably that the moth is *D. castanea.* The mesoscutum and tegulæ are grey, and the head and patagia are of a rose colour, but the rose coloration is absent in the pale forms (*v.* Plate, Figs. 1 and 2).

The Sexes.—It is not possible to distinguish the sexes in the field at sight. To do this it is first necessary to kill and examine them. It will be seen, however, that when set the hindwings of the males are uniformly pale, creamy or white, whereas those of the females are somewhat dark.*

* The writer wishes to express his indebtedness to Mr. Colin Smee, the Government Entomologist, for this observation.

III.—Life History.

Time of Planting; Oviposition.—As mentioned above, the planting of cotton in Nyasaland mostly takes place in December and January, the first buds appearing in the fifth or sixth week, in the case of Nyasaland Upland cotton. With the appearance of the buds may be expected that of the eggs also, and, indeed, they rarely fail to appear. From repeated observations it seems that, as a rule, no eggs are laid on the cotton plants until the first flower-buds make their appearance, a fact which points to some attractive principle developed in the buds themselves. Within a few days, after the arrival of the first buds, the plants may be seen to be liberally sprinkled with eggs, and whereas before this critical time no eggs are to be found, yet moths are not lacking. The eggs are laid on all parts of the plant, but more on the upper part than the lower. According to the writer's observations, the parts most favoured are the leaves, the main stem, and the petioles. Next in favour are the axils, and a few are to be found on the bracts. The eggs are usually deposited separately, but occasionally one sees a pair together. On one occasion the writer found sixty-two eggs laid on one plant, the majority being on the main stem, and eighteen of these were in one batch together. This must be taken as very unusual, and although the moth was never found, it is probable that it was deformed, and unable to fly.

Incubation Period; Hatching.—The incubation period varies according to temperature; thus from 20-24° C., it is seven to nine days, 24-26° C., five to seven days, and from 26-33° C., four to five days. It is worthy of note that this period may vary from five to nine days in one batch of eggs under the same conditions. When fresh, the colour is blue, but after two or three days this colour is lost, giving place to grey. When ready for hatching, the head of the larva looks dark through the white wall of the egg. At first a gentle heaving of the wall above the head can be seen, and after five or ten minutes the wall is broken. The heaving continues, with occasional rests, and as the jaws are brought into play, the breach is widened. The opening is at first confined to the thinner parts of the wall, the ribs resisting the onslaught, and little flakes of shell may be seen to drop away, leaving the reticulum intact. Persistent efforts, however, break down the stronger parts of the shell, and the observer may see the jaws at work tearing at it and expelling the fragments so detached.

The Newly Hatched Larva; its Longevity.—The newly hatched larva loses no time in starting out for its nearest meal. Kept in

tubes under observation, they were seen to travel for hours on end, and the total distance covered in about ten hours must be of the order of one hundred yards. Under such experimental conditions, if no food is obtainable, they eventually spin a web in an aimless manner and gradually die. The longevity of the first instar under these conditions varied from seven to thirty hours at a temperature of 24° C. There was one record at each end of this period, eighteen others being observed to die in ten to fifteen hours, while six took eighteen to twenty-four hours. Under natural conditions the caterpillar probably finds food during its first half-hour of existence. If the initial attack is severe, and there is an excess of larvæ over buds, the young, green parts of the stem are attacked, and the larva becomes a borer; this is only seen in the early part of the season. The writer has never found more than one young larva in a bud.

Method of Attack.—The method of attacking a bud is as follows. On reaching the bud, the young caterpillar makes its way between the bracts to a place where one of the bracts touches the surface of the bud. Here it effects an entrance, being assisted by the light pressure of the bract against it as it works. While making its way in, the young larva bites pieces from the bud and throws them away, so that after it has disappeared a litter of withered pieces of bud material marks the entrance. Later, it may move in succession to several buds and destroy them. An attacked bud is at once evident, since the stimulus applied to the bud when entering causes the bracts to flare back; and later these buds are shed.

Damage.—The caterpillar passes through four stages until fully fed, the whole process taking from four to six weeks, though occasional individuals may take less than two weeks. Larvæ hatched from the same batch of eggs may vary considerably in their period of growth. The damage done by them is very severe. As in the first instar, the older ones make their entry into the boll by biting pieces out of the wall and throwing them aside, gradually working into the middle. On opening a damaged boll, it is seen to be browned and blackened, and full of excreta. By this one can differentiate from a boll injured by *Chloridea obsoleta* (American Bollworm), which usually leaves most of its body, and consequently its dejecta, on the outside.

The Pupa Duration.—The caterpillar shows itself to be ready for pupation when it appears fat and greasy, with a creamy or a greenish ground colour, and a pinkish flush across each segment. Its length at this time is about 25 mm. After descending to the soil, it burrows down a short distance and makes a small compartment for itself in the earth by pushing and twisting. It then saturates the

earth around with saliva to a thickness of about a quarter of an inch from the wall of the cell. The wall being now patted and smoothed to its liking, it spins a web with which it completely lines its cell. When this is finished it becomes still, and in a few hours, or sometimes two or three days, the skin is shed, revealing the pupa. The depth of the cell below the surface of the soil is from one to three inches.

The duration of the pupal stage is remarkably elastic. The quickest emergence the writer has seen is thirteen days, but this was not enclosed in a cell. The longest on record in this country is ten months. At the Second Imperial Entomological Conference at London in 1925, Mr. Pomeroy reported a duration of fourteen months in Nigeria.

The following table shows the number of individual durations recorded:

Duration (weeks) ..	2	3	4	5	6	7
Number of emergences	2	12	7	13	0	0

Duration (months) ..	2	2½	3	3½	4	4½	5	5¼	6	6½	7	7½	8	8½	9	10
Number of emergences	8	0	1	3	8	6	8	3	3	2	15	0	2	1	3	1

Generally speaking, those pupating in the early part of the season emerge early, and those which pupate in the later part of the season take much longer to emerge, but there are many exceptions. The table indicates this:

A. *Pupation beginning in—*	B. *No. of individuals.*	C. *Pupal period in months.*
January	1	¾
	1	
	1	
	1	
February	2	[illegible]
	1	[illegible]
	2	1
	1	1¼
	1	8½
March	3	1
	1	1¼
	1	4
April	1	1
	1	6
	10	7
	2	8
	3	9
	1	10
May	8	2
	2	4
	1	4½
	6	5
	1	5½
	2	6
	1	6½
	5	7

From the figures in the above table it will be seen that there is a possibility of a second and a third partial generation in one season. These figures, however, must not be taken too seriously, as they were all obtained under laboratory conditions, but there is no doubt that there is a second brood about April and May, which is of small proportions compared with the main brood. The factors which affect the longevity of the pupa are not known. It is possible that a cotton diet which presents a feast for some eight months of the year may have a modifying effect on the life-cycle of the moth, which, if it came originally from the bush, would probably have a much more limited time, two months or so, during which its food plant was fruiting. No wild host plant has hitherto been found in any part of Africa. Another moth, not yet identified, the structure of whose eggs and larvæ is very similar to that of *D. castanea*, and whose depredations on the bolls of *Thespesia Rogersii* resemble very closely the attacks of the Red Bollworm on cotton, has a regular pupal duration of about nine months. This tree appears to be its sole food-plant, and fruits for about two months in the early part of the year. It is extremely fortunate that this species has not attained a liking for cotton, although the writer has been able to breed it upon cotton from the earliest stage, nor did it shrink in the least from attacking cotton buds and bolls given to it as food.

The Adult: Emergence.—The emergence of the moth takes place in warm, moist weather, or after rain. Although the rainy season begins in November or December, the bulk of emergences takes place in February and March, the total period extending over about four months. Actual catches of moths in the field are as follows:

	Moths.
December (1925)	11
January (1926)	200
February ,,	8,920
March ,,	5,415
April ,,	20 (about).

At the beginning and end of the season there appear to be more males than females, but during the period of maximum emergence the females predominate.

After it has come out of the ground the moth sits on the nearest plant, seeming to prefer those which are short and near the ground. In two fields which had cotton in 1925, but were under another crop in 1926, large numbers were found resting on small weeds, and eggs were even laid on some of them. Although the larvæ had hatched from some, there was no sign of them to be found. It would seem from this that the moth does not fly very far, but expects, as it

were, its former food-plant to be there again, as it does not appear to be able to resist egg-laying after a time. This is also borne out by the independent testimony of several observers, who have noticed patches in a cotton field much more heavily attacked than the rest of the field.

The Adult : Oviposition.—Egg-laying takes place for an hour or two after sundown, from forty to seventy eggs being laid. This goes on for six to ten successive evenings, the number laid towards the end of that time becoming less and less. The total number of eggs laid in one period is between two hundred and fifty and four hundred. In captivity, several moths taken in the field laid from one hundred to three hundred eggs, after which all of them died. Dissection revealed anything from fifty to three hundred mature eggs in the oviducts, together with a large number of immature eggs. It would seem possible that a moth requires to be fertilized on more than one occasion, and that under natural conditions she may lay perhaps a thousand eggs, spread over six or eight weeks.

After laying its eggs the moth settles to rest, and may be seen during the day sitting on a leaf, the anterior pair of legs being often folded and raised. The wings are folded tight against the body with the upper and distal margins touching (*v.* Plate, Fig. 3). They are sluggish in the daytime, except under a hot sun, and may easily be captured in a small box or taken in the fingers, if it is desired to kill them at once.

Attraction to Light.—Moths have been captured at night attracted to the light of electric lamps, paraffin lamps, and candles. It is not known under what conditions the moths are attracted to light. Acetylene light traps in the field, although attracting a very varied fauna, failed to capture a single *Diparopsis*.

IV.—Control.

(*a*) *Natural Control.*

It cannot be an over-estimate that during the season there is an average of three bollworms per plant. If all these came to maturity and the females laid on the succeeding crop, the plants would be smothered with bollworms. Actually the average survival is somewhere between fifty and a hundred moths per acre. The controlling forces of nature are, therefore, responsible for the suppression of 99 per cent. What these forces are seems difficult to discover, but those that have been noticed hitherto may be set down.

Parasites.—The writer has been unable to breed a single parasite from hundreds of eggs taken in the field. There have been very

wise three months of food which would then be available would be more than sufficient for a second generation to appear, so that the initial attack on the new crop would be increased enormously.

Thorough cultivation must not be overlooked as a possible means of breaking the pupal cells and damaging or killing the pupæ, though the fact that a healthier stand of plants resulting from this produces a better crop is, in the writer's opinion, of greater value than the benefits of a problematical slaughter.

Summary.

1. *Diparopsis castanea* Hamps. has a peculiarly interrupted distribution in Africa.

2. As a pest in Nyasaland it has probably always been of first class importance.

3. The moth commences egg-laying with the appearance of the first cotton buds.

4. The emergence of the moths extends over a period of about four months, the maximum occurring in February and March.

5. The incubation period of the egg is about a week, and the time of development of the larva three to five weeks.

6. The length of the total cycle depends mainly on the duration of the pupal period. This period is from one to ten months at least.

7. The females probably lay between 500 and 1,000 eggs, divided into two or more periods.

8. Parasites are rare, and so far have only been found attacking the larvæ. Those found were flies of the families *Tachinidæ* and *Phoridæ*.

9. Natural control is not sufficiently effective to allow of a good yield.

10. Artificial control must be directed towards trapping the moth. The method advocated at present is collection by hand.

APPENDIX

LIST OF COTTON PESTS IN NYASALAND, 1926.

I.—Pests of Major Importance.

A. Bollworms.

Chloridea obsoleta F.: American Bollworm.
Diparopsis castanea Hamps.: Red or Sudan Bollworm.
Earias biplaga Wlk. }
Earias insulana Boisd. } Spiny Bollworm.

B. Cotton-stainers.

Dysdercus intermedius Dist.
Dysdercus nigrofasciatus Stal.

II.—Pests Liable to become Major Pests in Some Seasons or in Some Places.

A. Bollworm.

**Platyedra gossypiella* Saund.: Pink Bollworm.

B. Cotton-stainers.

Nezara pallidoconspersa St.
Callidea dregei Germ.

C. Leaf-eaters.

Prodenia litura F.
Zomba gossypii Bryant (Halticinæ).
Zonocerus elegans Thunb.
Chrotogonus rendalli Kirby.

D. Sucking-bugs.

Aphis gossypii Glov.
Chlorita fascialis.

III.—Minor Pests.

A. Leaf-eaters.

Lepidoptera:

Achœa adipodina Mab.
Achontia grœllsii Feisth.
Anomis erosa Hubn.
Phytometra chalcites Esp.
Phytometra orichalcea F.
Hypolimnus missippus Linn.
Catopsilia florellia F.
Utetheisa bella Hamps.

Coleoptera:

Asbecesta cyanipennis Har.
Dereodus recticollis Mshl.
Isanaris ater Mshl.
Ootheca mutabilis Sahlb.

B. Leaf-rollers.

Sylepta derogata F.
Cacœcia occidentalis Wals.

* Pink bollworm is at present confined to the extreme north of Nyasaland, in which region no cotton may now be grown.

C. Leaf-miner.

Acrocercops bifasciata Wals.

D. Stem-borer.

Apion armipes Wagn.

E. Stem-girdler.

Tragicoschema Wahlbergi Fhs.

F. Plant-suckers.

Anoplocnemis curvipes.
Helopeltis sp.
Odontopus confusus Dist.
Oxycarenus sp.

G. Flower-eaters.

Coryna catenata Gerst.
Mylabris amplectens Gerst.
Mylabris tricolor Gerst.

IV.—General Feeders of Little Importance.

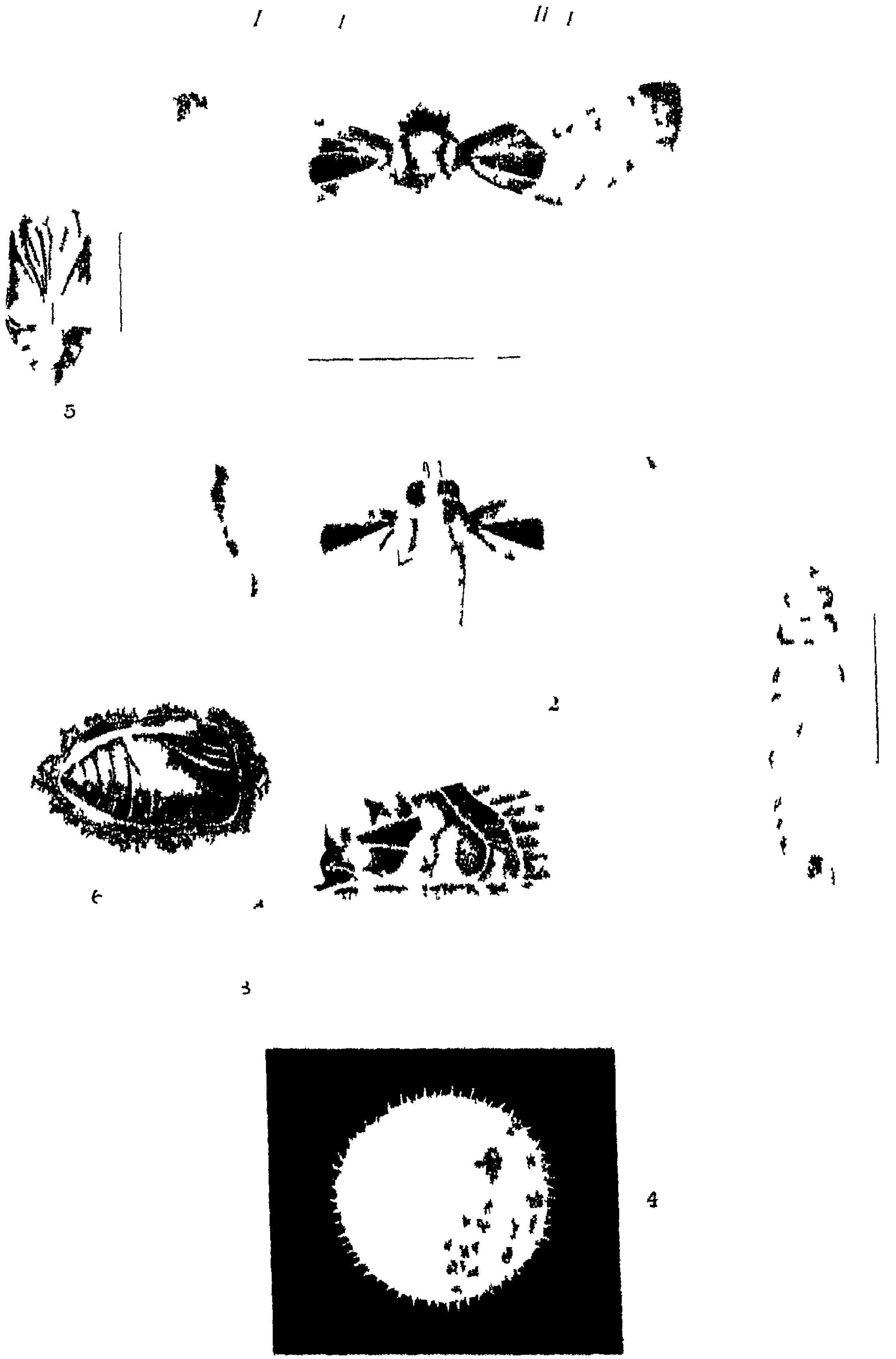
Lepidoptera:

Anatrachyntis coriacella Snel.
Bucculatrix loxoptila Meyr.
Diacrisia investigatorum Karsch.
Ephestia disparella Rgt.
Eublemma brachygonia Hamps.
Parasa vivida Wlk.

Coleoptera:

Epicauta sp.
Epuræa sp.
Nisotra testacea Chap.
Podagrica maculata Weise.

Received June, 1926.



(1) Female Moth
(2) Male Moth (pale form)
(3) Moth in resting position
(4) Egg highly magnified
(5) Pupa
(6) Cell with pupa part of cell wall removed
(7) Nearly full grown caterpillar (4^{th} instar)

SIXTH ENTOMOLOGICAL PROGRESS REPORT (AUSTRALIA)

SEASON 1925–1926 CONTINUED

RECEIVED FROM

E. BALLARD,

Cotton Entomologist appointed by the Corporation, attached to the Commonwealth Government of Australia.

My last report covered the period from the beginning of the present season up to the end of January. It will not be necessary, therefore, to go into any detail concerning those months.

The drought which was beginning at that time did not break until the first week of April. In consequence, a good proportion of the cotton crop did not mature.

There were one or two interesting features connected with insect pests as the result of this drought, which will be touched upon later.

Research Work.

It was my intention this season to concentrate my attention upon the "maize grub," *Heliothis obsoleta*, and *Dysdercus sidæ*, the large stainer, both from the point of view of control and of their bionomics. As the peach moth, *Conogethes punctiferalis*, does not attack cotton until fairly late in the season, it was hoped that time would be available to clear up various points in its life history which require elucidation. This insect is still under observation.

Now that *Tectacoris lineola* is disposed of, and the results of our investigations on it published, *Heliothis* and *Dysdercus* remain the two insects which demand most attention.

Taking the maize grub first. Shortly after writing my last report, I unfortunately fell a victim to the dengue fever epidemic, and by the time I was back at work *Heliothis* material was very difficult to obtain in the vicinity of Brisbane. The cotton crop at Gatton College, where some of the observations were being carried on, had failed, and my time was fully occupied with *Dysdercus*, so that some of the points about *Heliothis* which I had hoped to clear up remain to be dealt with another year. The preliminary trials which had been made to ascertain optimum soil temperatures for the development of

the pupæ could not be carried on, nor could my design of raising continuous broods throughout the year to test the period and date of hibernation, and the factors inducing it. From field evidence which one has been able to gather, both from one's own observations and those supplied by the courtesy of the Fruit Section (*Heliothis* being annually a severe pest of tomatoes), I am very doubtful whether on the coast, from Brisbane northwards, hibernation occurs at all. The *Heliothis* population is much reduced during the winter months, probably from the action of parasites during the summer, but true hibernation does not take place.

Behind the coastal ranges, where the main cotton belt is situated (the tendency being to abandon cotton-growing on the coast), *Heliothis* becomes scarce in May, and in any case ceases to be a pest after the end of March or the beginning of April. The time occupied by the various stages during the summer, from this year's observations at Brisbane, are as follows:

Egg, 2½ to 3 days; larva, 12½ to 25 days (during December and January); pupa, 12 to 15 days. In one case of pupæ exposed to full sunlight in soil in which pupation had taken place, this period was prolonged to 31 days—the temperature of the soil being raised to 117° F. Soil temperatures in the laboratory during December and January ranged about 85° to 91° F. The pupal period at Biloela, summer 1924-25, was found to be 9 days. Adults lived a little over a fortnight, the greatest number of eggs laid being 526. *Heliothis* has been known to lay up to 1,000.

Early in the season heavy casualties occurred among larvæ, both in the laboratory and in the field, from a bacterial disease following on a period of rain and high atmospheric humidity. Some 47 per cent. of larvæ collected in the field died in this way. Parasitism was very light; egg parasites seemed almost non-existent. One or two moths bred in the laboratory died a day or two after emergence, and the body contents were found to consist of fluid in a state of fermentation. It was not possible to follow this up, but it is possible that the disease which killed the mature larvæ might also affect adults.

As was stated in my last report, cotton sown early sets a sufficient crop to resist *Heliothis* attack. This was amply demonstrated this season at Biloela and elsewhere throughout the cotton areas. Observations for the past three seasons all confirm this. If the maximum square setting period precedes the time of maximum *Heliothis* population (late December to mid-February), then the crop escapes serious damage. In any case, a cotton plant sets more squares than it can mature, but if these are removed as fast as they are formed, then the

plant makes vegetative growth only. If there is, so to speak, an ample reserve of squares to draw on, then a good crop will be set in spite of *Heliothis*. Early sown cotton always escapes, late sown cotton hardly ever does.

At Biloela this season the rotation plot's cotton was sown early (7 acres); one acre of this was dusted early in January once, at the rate of 5 pounds to the acre. I stopped further dusting as it seemed to me unnecessary. From these plots 1,000 pounds to the acre was harvested, in spite of drought which caused a good many squares to shed.

The bulk of the Research Station cotton was planted late, but was protected by a trap crop of maize. In one block this trap crop was not planted according to the original plan, and the cotton had no protection after early January. This crop was not worth picking. A crop neighbouring the farm and planted at the same time suffered in the same way, while a block next to this planted early in very indifferently prepared land yielded heavily. This was typical of many areas. The factor of early planting undoubtedly gave rise to the myth that ratoon cotton was unaffected by insect pests. Actually it is just as palatable to stainers, *Tectacoris*, *Crocidosema plebiana*, and pink boll worm as any annual cotton. It is simply the fact that it sets its crop early that makes any *Heliothis* attack unnoticeable.

Counts were made on thirty plants in the cotton plot at Government House, Brisbane, to ascertain the number of squares a plant would set, and the crop which would be realised It was found that an average of 54·9 squares were set, of which just on 66 per cent. were shed—18·7 bolls per plant were matured, which is equivalent to a yield of about 900 pounds per acre. This was under drought conditions. It will be realised then that a very large proportion of the total number of squares set can be lost and still a good crop be harvested.

Our present knowledge of the "maize grub" may be summarised as follows, so far as its attacks on cotton are concerned:

Egg laying is continuous from October to April, at least 500 eggs being laid by one moth. The maximum population is reached in January and February. In normal years, parasites and predators have so far reduced the population that it is negligible as a pest after March. Hibernation probably begins behind the coastal ranges early in May; on the coast there is probably no hibernation at all. In very hot dry seasons, parasitism is much reduced, and therefore attacks will be heavier than in more normal ones. (Although few parasites

were obtained in the present season, and egg parasites in particular seemed very scarce, a marked contrast to last year, the predator *Triphleps australis*, China n. sp., which feeds on the eggs, was not affected by the dry weather, as it was plentiful this year.)

Early planting will generally avoid much loss from *Heliothis*, and in any case plants can afford to lose a high proportion of the total number of squares set provided that the loss occurs when a good start has been made. Late planted cotton will practically always suffer, because the squares are removed as they are formed, and the maximum bud period coincides with maximum population curve in *Heliothis*. Recently emerged larvæ feed in the terminal buds of the cotton plant, and all larval stages wander about a good deal. *Heliothis* prefers squares and flower buds nearly open to bolls. In spite of the fact that they seldom bite through the bracts to get at a flower bud, but force their way between them, their wandering habit lays them open to control by poisoning. This is especially the case with the earlier stages. Very wet conditions and damp food induce a disease which usually affects the last instars, although in the laboratory large numbers of young larvæ died in this way. Soil temperatures up to 117° F. apparently do not affect pupæ—but this matter requires further elucidation.

Pupation generally takes place in the shade, where the soil temperatures $1\frac{1}{2}$ inches below the surface were 89° to 91° in summer-time at Biloela.

The use of a maize trap crop was a complete success this year, in spite of the failure of the third planting owing to drought. Normally, it seems that dusting with calcium arsenate as a means of control will not be necessary before the end of December, and two dustings at fourteen days' interval will be sufficient. The first dusting should destroy all, or most, of the young larvæ then at work, and the last would catch the majority of the larvæ from eggs laid between the two dates of dusting.

Moths live for fourteen to fifteen days, and begin to lay three days after emergence. Larvæ which had burrowed the night before the first dusting would be laying eggs on the night after the second. This dusting programme should dispose of the majority of the maize grubs present, as very few of those from eggs laid between the two dustings should survive.

CONTROL EXPERIMENTS.

As a trap crop experiment was in progress at Biloela, and as in any case I could not leave Brisbane to superintend matters, dusting experiments with a view to making the application as cheap as possible were to be carried on at Gatton Agricultural College, which is fairly near Brisbane, where a good attack was working up on the Acala cotton planted there. The combined results of dengue and the drought effectually destroyed this plan.

Only a very small maize grub attack occurred in the cotton plot at Government House, and although this did not develop after dusting, it was so small in any case that no definite conclusions could be drawn from it.

There is no doubt about the efficacy of calcium arsenate. The problem is how to make as few applications as possible, and to find the maximum amount of dilution that can be combined with maximum toxic effect. It is most desirable not to make a recommendation to the farmer without at the same time giving him a balance sheet so that he can see how much it is likely to cost him.

The trap crop experiment this season at Biloela was designed as follows: To every four acres of cotton on the farm, one acre of maize was to be cultivated. Maize planting was to take place at three different periods: rather more than one-third was to be sown at the time of planting cotton, a similar quantity five weeks later, and the remainder five weeks after that. As these matured, they were to be cut and put into a stack silo.

The first planting was carried out as designed, and over most of the area, the second also. The third was hit by the drought, and did not grow. In one block, the second planting was missed, and as the third failed to come through, the cotton was very badly hit, and failed to produce a crop. This was regrettable, but provided a useful check experiment. The first planting of maize was cut as planned, but the second was not. The stack silo was a failure owing to the absence of the farm manager through illness.

Crops protected by the trap crop realised over 1,200 pounds to the acre (10½ acres). The 3 acres where the second maize planting was not carried out realised nothing. Trap crop experiments will not be continued next year, as it is intended to rely on the use of calcium arsenate dust.

Dysdercus sidæ.—*Dysdercus* migrants arrived very late this season at Biloela, Gatton, and Brisbane.

The first migrants began to arrive at Gatton between the 6th and

9th of February, and in Brisbane migration lasted about a month, from the end of February to the end of March.

The Gatton cotton never matured properly, and was given up, so that one was unable to follow up the progress of migration in that locality. At Gatton the migrants must have come from a considerable distance. No *Dysdercus* could be found on *Malvaceæ* in the College grounds during the winter, although *Oxycarœnus* was sheltering in *Hibiscus Rosa-sinensis* at that time. At the end of February, when the crop was abandoned, only very few *Dysdercus* could be found. There was quite a fair population on the Government House cotton in Brisbane during March and April, but nymphs were very scarce, and the migrants left very few descendants. Couples in a large breeding cage set up in the field, where observation was easier than in the field itself, laid eggs, but very few nymphs matured. During all this period the temperatures were high, and the crop shed its leaves, there was no rain, and all insects were very lethargic, spending their time by day in what shelter they could find. There was not a great deal of this, as the plants shed a large proportion of their leaves, and were dry and yellow. Flowering and squaring ceased, and the whole crop bore a typically drought-stricken appearance.

Up to the time of writing, hardly any descendants of the original migrant brood are to be found.

One can only imagine that the excessively unfavourable weather, hot unshaded soil, and lack of moisture effectually prevented many nymphs from coming to maturity.

Large numbers of broods were raised in the laboratory, and provided they were given plenty of moisture, no difficulty was experienced in raising them, except for the fits of cannibalism with which they were seized every now and then. These broods are being carried on, and will be continued until next March, and the effect of heat and humidity on both adults and nymphs studied.

One fact stands out, and that is their absolute dependence on moisture. Lack of it rapidly kills them, and drives them almost invariably to cannibalism. It seems to make no difference to the hatching time of the eggs whether they are kept in a moist atmosphere or a dry one, but temperature affects them directly—with the onset of winter the time is extended to fourteen days as against five to five and a half in the late summer.

All over the cotton belt *Tectacoris* and *Dysdercus* were very late in arrival. In consequence the first picking coming in to the ginneries was a very high grade, being almost without stain. The first germination experiments and examination of seed gave a very low

percentage of *Fusarium moniliforme* symptoms. Later pickings were not so good, but better than last year. This could be accounted for by the presence of *Oxycarænus luctuosus*, which bred up in the open bolls, but was not so abundant as in the preceding season. In this connection it may be of interest to record that I was very struck on my first inspection of Queensland cotton, in 1924, with the scarcity of *Dysdercus*. The 1923-24 season was characterized by a drought in early summer.

One interesting point in connection with *Fusarium* infestation is that all seeds used as food for nymphs and adults raised in the laboratory developed *Fusarium* symptoms, while a test made of seeds kept under similar conditions of moisture, but with no bugs present, did not. This makes it appear that the *Fusarium* spores are present in the fuzz on the seed.

A good deal of information has been collected about *Dysdercus*, but it is not proposed to publish any of it until the end of the next season. *Dysdercus* is still under investigation, and it is hoped to be able to carry this work on right through next season.

Last year, some preliminary experiments made to test the efficacy of baits for controlling *Dysdercus* gave very promising results. These, however, were not confirmed this year, and at the moment we are as far as ever from a simple and cheap remedy.

Other Pests.

Oxycarænus luctuosus undoubtedly damages the cotton seed, but under Queensland conditions it is most improbable that any economical remedy can be devised to control it. The simplest method of circumventing it is to increase the seed rate and ensure a good stand. The present rate of 20 pounds to the acre appears to be quite sufficient.

Conogethes punctiferalis has done little damage this year, except in certain places, very largely because there was no cotton for it to attack. At Government House it was forced to burrow into the terminals after the manner of *Earias*, as there were no green bolls, and practically no squares at the time when it was at the height of its attack. Although it first appeared in the field at about the usual date (last week in February), no eggs could be found after April, although moths were emerging from time to time. *Conogethes punctiferalis* will always get a portion of the crop, but is only a serious pest in late planted cotton. The simplest remedy that can be thought of at present is early planting, and this has, in addition, many other advantages.

Earias hugelli was present throughout the season, but never was a major pest. *Dysdercus* adults were often seen feeding on the pupæ.

Crocidosema plebiana only did slight damage. In any case, its activities generally cease by the middle of January.

Tectacoris lineola.—Practically none appeared until too late to do any damage.

Euxoa radians.—Cut worms caused a good deal of loss in November and December. They appear to be sporadic, but a study of the conditions leading to their sudden appearances might be of value, although not of immediate importance.

Prodenia sp.—Caterpillars of this moth did some damage at Government House to squares and leaves, but no reports were received of similar damage elsewhere.

Red Spider (*Tetranychus telarius*).—Early in the season an attack from this cosmopolitan pest developed on the Government House cotton. The plants were then growing vigorously, and were not badly affected, although *Tetranychus* soon spread over the whole ¼ acre. The long period of dry weather checked it, but with the breaking of the drought it has begun to spread again.

Pink Boll Worm.—Except in one or two places, and notably in a ratoon area, where an almost continuous supply of food had been provided between the cotton seasons, Pink Boll Worm is conspicuous by its absence. Graders at the ginneries had received instructions to send me as many as they could find, and up to date I have received under thirty. The early closing of last season, the drought, and the disinfection of the seed, have probably all contributed their quota to this desirable result of lessened Pink Boll Worm damage. The sudden cessation of the present season, and the fact that many farmers are already beginning to prepare their land for the next, should help still further to get this potentially dangerous pest under control. No new areas of infection have been reported.

General.

Being without an assistant has been a great handicap this season, as the laboratory work necessary in connection with the study of the life histories of *Heliothis* and *Dysdercus* kept me in Brisbane; consequently, I was unable to visit Biloela as often as I should have liked. I was able to arrange with the Chief Entomologist to the Queensland Government for essential work to be carried on during my absence at Biloela in January, but the assistant lent to me could only give part of his time. I should add that Mr. Veitch, the Chief Entomologist, has done all he could for me, and is always ready to assist me

in any way he can, but he is very shorthanded himself, and is unable to get suitable applicants for the vacant posts. We hope that next season these posts will be filled.

The Cotton Section has helped me in many ways. I have had the use of the cotton plot at Government House as an outside laboratory, and it has been invaluable. A portion of the cotton seed store has been placed at my disposal for use as a laboratory, but for the coming season certain apparatus will be necessary.

In general, the insect pest situation is becoming clearer as we gain further knowledge of the field behaviour of the chief insects concerned. The scattored nature of the cotton belt and the large areas of uncultivated country make questions of control in some ways more difficult, and quite different from those obtaining in an island like Barbados, or in closely settled countries such as cotton areas in India.

Everything points to two insects claiming the most attention, and they are *Heliothis* and *Dysdercus.* Apart from sporadic outbreaks of cut worms, or defoliators such as *Monolepta rosea,* the control of these two will assure a good crop to the farmer, both in yield and quality, provided the farming is properly attended to. For the moment other pests can be disregarded.

These conclusions I have come to after seeing the results of two drought seasons and one normal one, or perhaps I should say one favourable one.

BRISBANE,
May 28, 1926.

SPINNING TESTS

INDIAN COTTONS

The following tests on samples of cottons received from India have been carried out at the request of the Indian Central Cotton Committee with the co operation of the Oldham Master Cotton Spinners' Association

Particulars of the cottons used as controls are given in italics

SPINNING TESTS OF INDIAN COTTON (MARCH 1926)

Firm making Test	Growth	Per Cent Loss up to Card Slive	Nominal Counts	Actual Counts at Spindle Point	Lea Strength Test in Lb	Actual Turns per Inch	Estimated Value compared with Price of Cotton Next Month Future Universal Standard: Staple	Grade and Colour	Working	Net Value
No 1	*American Boweds*	*8 5*	*Weft 25*	*25 26*	*54 9*	*17 5*	*40 on*	*40 on*	*20 on*	*100 on*
			„ 24	*24 31*	*52 5*	*16 25*				
			25 hard	*26 01*	*57 0*	*22*				
			Twist 30	*30 77*	*41 5*	*23*				
	Gadag No 1	16 375	Weft 25	25 82	53 4	17 5	40 on	60 off	20 on	Pass
			24	24 89	54 3	16 25				
			25 hard	26 06	58 6	22				
			Twist 30	30 84	44 8	23				
	American Boweds	*8 5*	*Weft 28*	*28 37*	*54*	*22*	*40 on*	*40 on*	*20 on*	*100 on*
			26	*26 90*	*57*	*23*				
			25	*25 23*	*61*	*17 5*				
			30	*30 98*	*43*	*19*				
	285 F (Punjab Am)	13 5	Weft 28	29 04	60 3	22	80 on	30 off	300 off	250 off
			26	26 32	74	23				
			25	24 75	72	17 5				
			„ 30	30 08	49	19				
No 2	*American Texas*	*9 56*	*Twist 30*	*28 68*	*57 75*	*20 3*	*80 on*	*30 on*	*25 on*	*135 on*
			24	*22 87*	*76 75*	*17 18*				
	1027 ALF (Surat)	12 37	Twist 30	31 37	41 75	20 3	40 on	30 off	25 on	35 on
			„ 24	24 31	66 75	17 18				

SPINNING TESTS OF INDIAN COTTON (MARCH, 1926)—(*Continued*).

Firm making Test.	Growth.	Per Cent. Loss up to Card Sliver.	Nominal Counts.	Actual Counts at Spindle Point.	Lea Strength Test in Lbs.	Actual Turns per Inch.	Estimated Value compared with Price of Current Month Futures, Universal Standard. Staple.	Grade and Colour.	Working.	Net Value.
No. 3	*Mid. American*	*10·125*	*Twist 12½*	*12·88*	*129·5*	*13·35*	*35 on*	*Pass*	*Pass*	*35 on*
			,, 16	*16·93*	*95·25*	*15*				
			Weft 11	*11·76*	*136·25*	*10·8*				
			,, 18	*18·91*	*70·75*	*13·5*				
	Sircar 14	1st Test 23·3125	Twist 12½	13·74	132·5	13·8	25 on	175 off	Pass	150 off
			,, 16	17·77	100·12	15·0				
			Weft 11	12·39	136·0	11·65				
			,, 17	18·35	98·37	13·30				
		2nd Test 20·25	Twist 12½	12·34	146·0	13·85				
			,, 16	16·25	110·12	15·15				
			Weft 12	12·80	137·25	11·25				
			,, 16	16·50	103·5	12·50				
	Sircar 25	1st Test 13·375	Twist 11½	12·31	126·5	12·65	Pass	50 off	Pass	50 off
			,, 15½	16·65	92·62	14·65				
			Weft 10	10·94	144·5	11·15				
			,, 16	17·20	84·0	12·0				
		2nd Test 12·125	Twist 12½	12·88	125·5	12·75				
			,, 16	17·65	83·62	14·95				
			Weft 12	13·23	112·0	11·0				
			,, 16	17·50	73·25	12·10				
No. 4	*Universal Mid. Boweds* ..	*8*	*Weft 24*	*24*	*58·75*	*19·37*	*20 on*	*Pass*	*Pass*	*20 on*
			,, 22	*21·9*	*61·75*	*17·6*				
	Cambodia No. 1	12·05	Weft 30	29·9	52·75	22·2	15 on	Pass	10 on	25 on
			,, 24	24·84	54·75	19·3				
			,, 20	20·9	70·25	16·5				
	Dharwar No. 1	17·3	Weft 24	25·15	54·75	19·9	Pass	150 off	50 off	200 off
			,, 22	23·3	60·0	19·3				

TESTS ON INDIAN GROWN COTTON (MARCH 1926)

SPINNERS COMMENTS No. 1 Firm

	On the Raw Cotton					On Behaviour in Working	On Yarn Produced
	Staple (In.)	Seed and Leaf	Colour	Ginning	General		
Gadag No. 1	1[illegible]	Shy of Mid. Am.	Cream	Good	If a purer strain could be cultivated and leaf and seed kept out in greater degree this cotton would make an excellent substitute for S.M. Boweds	Worked well	[illegible] up to 30 [illegible] better than [illegible] [illegible] cleanliness inferior [illegible] Boweds. Resultant yarn contained more neps and bits of seed and is not so level as American with which was compared
285 F (Punjab Am.)	$1\frac{1}{16}$	About equal to Mid. Am.	Light cream	Good but too many stained spots	Too full of minute pieces of seed with hairs attached which ruin the evenness and appearance of the [illegible]	Worked well	The [illegible] from this cotton is very [illegible] [illegible] much more prevalent than would appear [illegible] looking at the cotton in the bale. This fault is very pronounced on [illegible] card. The [illegible] [illegible] and [illegible] wheels on card were [illegible] so that effect could be noted but no improvement resulted. Three cards were tried but result was same in each case

SPINNERS COMMENTS *No 2 F* [illegible]

102[illegible] ALF (Surat)	1	Leafy	Creamy	Unsatisfactory Leafy in patches [illegible] ins in diameter	The leaf seems to hang in patches but with a good cleaning plan can be separated with success	The behaviour during carding and spinning was very good but was considerably softer than the Texas cotton spun at the same time	Anything over 30 s will in our opinion begin to show the Indian cotton 10[illegible] ALF to disadvantage The strength will be seen to be about 11 lbs below the test iron. American cotton of Texas growth Growth of cot on other than American do not generally command the same price when the staple and grade are considered equal

SPINNERS COMMENTS *No 3 F* [illegible]

Surat 14	1[illegible]	[illegible]	[illegible]	[illegible]	Diameter [illegible]	Works very well in carding and spinning but [illegible]	This cotton would spin 36 38 Weft or [illegible] Twist—more suitable for Twist [illegible] American [illegible] much darker in colour and [illegible] considerably more leaf Would [illegible] market value [illegible] American [illegible] depending upon the purpose [illegible]
Surat 2[illegible]	1	[illegible]		[illegible]	[illegible]	[illegible]	Would [illegible] 34 Weft [illegible]

TESTS ON INDIAN GROWN COTTON (MARCH, 1926)—*Continued.*

SPINNERS' COMMENTS. *No. 4 Firm.*

	On the Raw Cotton.					*On Behaviour in Working.*	*On the Yarns Produced.*
	Staple (Ins.).	*Seed and Leaf.*	*Colour.*	*Ginning.*	*Generally.*		
Cambodia No. I	Full 1	Beautifully clean. almost free from leaf and seed	Beautiful creamy white	Very good indeed	Very fine silky texture, and good spinning cotton up to 30's counts. Nice staple, good creamy white, bright and clean, not too lossy in spinning processes. Staple very regular. A good substitute for Amer. Boweds except a little too creamy	Good spinning cotton. Equal to Universal Mid. Boweds Amer. in spinning, but not in colour; required less twist than Dharwar or Universal Mid. Boweds	Colour rather creamy, but bright and nice lustre. Thread moderately level and free from nep. fairly clean. Strength not quite so good as Amer. Boweds. A marketable yarn up to 30's counts
Dharwar No. 1	1	Much broken leaf and seed, also much sand	Dull, heavy, creamy colour which is objectionable	Not satisfactory; too much broken leaf, seed and sand	Rather fine silky texture: spins fairly well up to 24's counts. Nice staple. Its bad colour, broken leaf, seed and sand are very objectionable, making the cotton very lossy in spinning process. Staple very regular, but not fit to substitute American Boweds owing to the above faults	Spins fairly well, but makes far too much loss in sand and leaf. This cotton requires more twist than Cambodia or Universal Mid. Boweds American	Dull brown colour. Thread rather unlevel in 24's counts. Moderately clean, lacking lustre and free from nep. Strength not quite so good as Amer. Boweds. A marketable yarn up to 24's counts

SPINNING TESTS OF INDIAN COTTON (MAY, 1926).

With reference to the 285 F, some doubt has been expressed that the bales supplied for the previous test came from an end of the season shipment, and were not really representative of the type. Therefore it was considered advisable to have further tests of both the 285 F and 289 F, and for this purpose 100 lbs. of lint was supplied to certain firms, and their results are given below.

The tests were made on machine-ginned (*i.e.*, roller-ginned) cotton, but all Punjab-American Varieties can now be obtained either roller-ginned or saw-ginned; tests carried out at the Technological Laboratory, Bombay, indicate that the saw-ginned cotton is the less neppy.

Samples of the raw cotton, and of the product after it has passed through the various processes, can be seen at the offices of the British Cotton Growing Association, 333-350, Royal Exchange, Manchester.

Firm making Test.	*Growth.*	*Per Cent. Loss up to Card Sliver.*	*Nominal Counts.*	*Actual Counts at Spindle Point.*	*Lea Strength Test in Lbs.*	*Actual Turns per Inch.*	*Estimated Value compared with Price of Current Month Futures, Universal Standard.*			
							Staple.	*Grade and Colour.*	*Working.*	*Net Value.*
A	Good Mid. American Texas	8	Twist 36	37	44·25	22·7	—	—	—	—
			Weft 38	38·8	41	20·67				
			,, 40	41	39·75	21·45				
	285 F (Punjab-Amer.) ..	14·09	Twist 36	35·4	49·25	23·17	130 on	Pass	75 off	55 on
			Weft 38	37·45	49·25	21·9				
			,, 40	39·2	45	22·05				
B	289 F (Punjab-Amer.) ..	14·75	—	—	—	—	—	—	—	—
C	Mid. American ($1\frac{3}{16}$ inch)	10·45	Ring Twist 32	—	56	23·3	—	—	—	—
	285 F (Punjab-Amer.) ..	16·66	,, ,, 32	—	55	23·3	—	—	—	—
	289 F (Punjab-Amer.) ..	16	,, ,, 32	—	60	23·3	—	—	—	—
D	American Georgia ..	—	Weft 28	29	37½	18	—	—	—	—
			,, 24	26·16	45	17				
	285 F (Punjab-Amer.) ..	13·9	,, 28	30·33	48¾	18	—	—	—	—
			,, 24	27·04	59	17				
	289 F (Punjab-Amer.) ..	18·4	,, 28	32·24	47	18	—	—	—	—
			,, 24	27·07	58½	17				
E	285 F	12·5	Twist 24	22·6	71	17·58	Very good	S. Low Mid., fair colour	Good	50 on
			,, 40	34·7	54·5	20·86				
			Weft 40	38·2	42·5	20·9				
			Twist 28	25	65·4	19·4				
	289 F	14	Twist 26	25·01	67·3	19·4	Good	Middling	Good	50 on
			Weft 36	33·1	51	19·3				
			,, 30	27·9	57·6	19				
			Twist 26	24·2	68·5	19·4				

TESTS ON INDIAN GROWN COTTON.

SPINNERS' COMMENTS. *A Firm.*

	On the Raw Cotton.					On Behaviour in Working.	On the Yarns Produced.
	Staple (Ins.).	*Seed and Leaf.*	*Colour.*	*Ginning.*	*Generally.*		
285 F (Punjab-Amer.)	Full $1\frac{1}{8}$ in. to $1\frac{3}{16}$ in.	Large amount	Dull cream	Could be improved	Silky texture, fibre very strong	Works very well in carding and spinning; requires much less twist than American Texas	Would spin 46's to 48's Weft or 35's to 40's Twist; more suitable for twist yarns. Thread fairly level. a little nep showing, in our opinion, through faulty ginning.

SPINNERS' COMMENTS. *B Firm.*

289 F (Punjab-Amer.)	$1\frac{5}{16}$ in. dia. x. fine	Too much leaf and seed	Dull cream	—	Twist good, but tests only taken up to intermediate bobbin	—	We think would spin 54's to 70's Twist yarn under proper conditions and with better ginning.

SPINNERS' COMMENTS *C Firm*

285 F (Punjab Amer) —	$1\frac{1}{8}$ in	—	All practically alike, but Ameri can has less lustre	—	—	Difficulty with 285 F Fibres falling away apparently less natural twist	The American is easily the cleanest and most even yarn The two Indian cottons are similar, both are uneven, very neppy indeed, with plenty of leaf still showing
289 F (Punjab Amer)	$1\frac{1}{8}$ in	—	Ditto	—	—	No trouble	Ditto

SPINNERS COMMENTS *D Firm*

285 F (Punjab Amer)	$1\frac{1}{16}$ in	Equal to Mid Amer	Light cream	Good	Contains a large amount of stain	Worked well	Very much finer counts can be spun than here reported upon, but excessive nep seriously prejudices the value of this cotton
289 F (Punjab Amer)	$1\frac{1}{16}$ in	Equal to Mid Amer	Light cream	Good	Rather dirtier than 285 F but not so many stains	Good	Ditto

SPINNERS COMMENTS *E Firm*

285 F (Punjab Amer)	—	—	—	—	—	—	Compares very favourably with Amer Boweds for Weft yarns, being bright and of good colour and staple Quite up to staple Boweds, suitable for 40 s Weft
289 F (Punjab Amer)	—	—	—	—	—	—	More suitable for Twist yarns, being longer in staple than Boweds, and equal in strength to Good $1\frac{1}{8}$ in Texas Suitable up to 30 s Twist

COMPARATIVE COTTON PRICES—III

BY

JOHN A. TODD, M.A., B.L

We continue in this issue the record of cotton prices first given in October, 1924.

Taking first the general level of cotton prices, there has been an all-round decline of about 25 per cent. against a fall of about 8 per cent. in the general Index Numbers. This is, of course, the result of the large American crop of 16,103,679 bales following upon the similar improvement in 1924. The growing effect of this can be seen in the monthly prices (Table II.). The highest price of spot American in Liverpool was 18·63 on September 17, and the lowest 9·17 on July 5, but October futures went as low as 8·44d on July 5. The season closed well above the lowest owing to the unfavourable progress of this year's crop up till that date, but things took a more favourable turn in the last week of July. However, in August prices, after falling steadily to the middle of the month, rose sharply towards the end on account of the U.S. Census Bureau crop report of the 23rd.

There has again been a marked swing of the pendulum in regard to the relative prices of American and Egyptian. Last season Egyptian premiums went to an excessive height (see Table II.), but the record crop of 1925, probably exceeding 8 million kantars, produced the natural reaction, in spite of the Government's effort to maintain prices by fairly substantial purchases, which are not likely to prove profitable on present prospects. It is, of course, impossible to dogmatize about the normal premium of Sakel over American, but this season's experience seems to favour the idea of about 60 per cent. as a reasonable premium when the crops are about normal in their relative size.

Uppers have also settled down to what may be regarded as something like a normal relation to American, the premium running now about 25 per cent. This season Uppers have shown a marked tendency to follow American rather than Sakel prices, which is significant of the changed position that Uppers now occupy in the cotton world. There is now no clear line of separation between American and Egyptian cotton. Sakel is at one end of the scale in

quality and ordinary American Upland at the other (omitting the lower grades of Indian, of course); but there is now a large number of varieties of cotton lying between these two—*e.g.*, Brazilian, Peruvian, East African, and Uppers, which can be used to supplement the supply either of the better classes of American such as Texas $1\frac{1}{8}$ inches or the lower grades of Sakel. A marked feature of the past season has been the substitution of East African cotton for Uppers, and even for the lower grades of Sakel; while the higher grades of Sakel have now to face the competition of Sudan Sakel in increasing volume.

The price of Indian relative to American has also been more normal in 1925-26. Unfortunately space will not allow of the inclusion of a quotation for the better varieties of Indian, such as Punjab American.

Looking ahead, it is interesting to speculate on the effect of the lower level of American prices (and, therefore, of world cotton prices) upon the continued development of pioneer cotton-growing areas, especially in the Empire. There is no doubt that "shilling cotton" has been the best friend of Empire cotton-growing, and now that the limit has been definitely broken, and lower prices seem probable for the coming season, the Empire fields will have to face their real testing time.

TABLE I.—HISTORY OF COTTON PRICES, 1899–1926.

SEASON'S AVERAGES.

Season.	*Liverpool Prices (Pence per Lb.).* *Sea Island.*	*Brazil.*	*American.*	*Indian.*	*Egyptian.*	*Alexandria.*	*American Price of Upland.*	*Year.*	*Index Numbers of General Prices.*
		Pernam Fair.	Middling.	No. 1 Fine Oomra.	F. G. F. Brown	Dols. per Kantar	Cents per Lb.		
1899–1900	16·7	5·06	4·87	4·40	6·81	12·28	7·60	1900	100·0
1900–01	16·4	5·50	5·16	4·37	6·87	13·80	9·30	1901	96·7
1901–02	19·3	4·87	4·78	4·19	6·31	10·42	8·10	1902	96·4
1902–03	*25·00	5·57	5·44	4·47	8·44	13·65	8·20	1903	96·9
1903–04	28·40	5·16	6·94	5·56	8·56	16·65	12·16	1904	98·2
1904–05	27·12	5·25	4·93	4·62	7·37	13·97	8·66	1905	97·6
1905–06	26·38	6·23	5·94	5·00	9·25	15·99	10·94	1906	100·8
1906–07	36·70	6·97	6·38	4·87	10·37	19·16	10·01	1907	106·0
1907–08	35·59	6·79	6·19	5·03	8·81	18·21	11·46	1908	103·0
1908–09	23·39	5·81	5·50	4·94	8·44	15·46	9·24	1909	104·1
1909–10	32·85	8·34	7·86	†6·06	13·12	23·30	14·29	1910	108·8
1910–11	35·62	8·27	7·84	6·78	10·75	20·66	14·69	1911	109·4
1911–12	23·73	6·70	6·09	5·44	9·56	17·25	9·69	1912	114·9
1912–13	25·00	7·11	6·76	5·91	9·79	18·28	12·20	1913	116·5
1913–14	23·47	7·47	7·27	5·62	9·45	19·02	13·49	1914	117·2
1914–15	22·00	5·71	5·22	4·19	7·34	12·01	7·94	1915	143·9
1915–16	27·00	8·22	7·51	5·79	10·42	19·28	11·99	1916	186·5
1916–17	50·00	13·03	12·33	9·92	21·56	37·81	18·41	1917	243·0
1917–18	80·00	24·13	21·68	16·10	§30·97	38·52	28·86	1918	267·4
1918–19	65·00	23·96	19·73	17·15	27·85	37·20	30·36	1919	296·5
1919–20	—	30·00	25·31	18·05	60·34	87·81	38·21	1920	365·7
1920–21	—	13·24	11·89	8·21	30·24	34·50	16·08	1921	220·7
1921–22	—	11·40	11·37	8·72	19·75	31·28	17·78	1922	185·0
1922–23	—	14·62	14·02	10·25	17·29	30·71	24·06	1923	185·3
1923–24	—	18·20	17·66	12·37	21·55	39·79	31·67	1924	193·6
1924–25	—	14·67	13·76	11·01	20·82	39·49	24·27	1925	186·1
1925–26	—	11·08	10·77	‡8·97	20·05	‖30·59	18·85	1926	¶171·1

* South Carolina.
† No. 1 Good Oomra.
‡ No. 1 Fine Oomra.
§ F. G. F. Sakel.
‖ Ten months' average. These figures are F. G. F. Brown till 1914, since then composite figures embracing G. F. Sakel, G. F. Ashmuni, and G. F. Brown.
¶ Seven months' average.

TABLE II.—SPOT PRICES OF AMERICAN AND EGYPTIAN COTTON IN LIVERPOOL, ALEXANDRIA, AND NEW ORLEANS ON THE LAST FRIDAY OF EACH MONTH.

Month.	*Liverpool.* *American Fully Middling.*	*Liverpool.* *Egyptian F. G. F. Sakel.*	*Premium per Cent.*	*New Orleans American Middling.*	*Alexandria F. G. F. Sakel.*	*Premium per Cent.*
1923–24.	Pence per Lb.	Pence per Lb.		Cents per Lb.	Dollars per Kantar.	
August ..	15·18	16·75	*10*	24·75	31·50	*27*
September ..	17·11	18·35	*7*	28·50	34·87	*22*
October ..	17·88	18·75	*5*	30·50	34·87	*14*
November ..	21·72	26·70	*23*	35·75	50·37	*41*
December ..	21·17	24·30	*15*	36·00	45·62	*27*
January ..	19·81	23·35	*18*	33·50	44·62	*33*
February ..	17·63	20·50	*16*	29·63	40·50	*36*
March ..	16·46	20·60	*25*	27·50	40·00	*46*
April	18·20	23·40	*28*	30·88	44·62	*44*
May	18·23	23·10	*27*	30·88	44·87	*45*
June	17·43	23·60	*35*	28·80	44·37	*54*
July	18·29	25·00	*37*	30·00	47·27	*58*
1924–25.	*Middling.*					
August ..	15·76	25·15	*60*	24·82	47·75	*92*
September ..	14·09	25·25	*79*	24·80	42·50	*72*
October ..	13·58	25·60	*89*	22·85	46·00	*102*
November ..	13·59	26·20	*93*	23·70	47·87	*102*
December ..	13·24	29·35	*122*	23·75	57·37	*142*
January ..	12·92	31·75	*146*	23·75	61·87	*161*
February ..	13·94	34·90	*150*	25·30	67·63	*168*
March ..	13·88	36·35	*162*	25·10	72·37	*189*
April	13·40	31·60	*136*	24·45	64·12	*163*
May	13·04	30·25	*132*	24·05	60·37	*151*
June	13·53	32·05	*137*	23·90	63·12	*164*
July	13·53	32·45	*140*	24·25	59·89	*152*
1925–26.						
August ..	12·60	28·65	*128*	22·25	52·00	*134*
September ..	12·91	28·00	*117*	22·92	47·75	*108*
October ..	10·35	22·75	*120*	19·07	39·37	*107*
November ..	10·74	19·75	*88*	20·05	35·62	*77*
December ..	10·27	17·65	*72*	20·00	32·87	*64*
January ..	10·63	18·25	*72*	20·07	34·50	*72*
February ..	10 33	17·30	*68*	18·95	33·00	*74*
March ..	10·16	15·60	*53*	18 05	30·50	*69*
April	9·94	16·25	*64*	17·90	31·25	*75*
May	10·33	17·10	*65*	18·00	31·25	*74*
June	9·56	16·35	*71*	17·55	30 00	*71*
July	10·02	16·40	*64*	18·69	29·87	*60*
1926–27.						
August ..	10·17	16·35	*61*	18·29		

TABLE III.—MONTHLY SPOT PRICES OF VARIOUS KINDS OF COTTON IN LIVERPOOL, 1923–26.

ON THE LAST FRIDAY OF EACH MONTH. FROM THE LIVERPOOL COTTON ASSOCIATION'S WEEKLY CIRCULARS.

(For American in Liverpool and New Orleans—and Egyptian in Liverpool and Alexandria—see Table II.)

Seasons.	*Egyptian Uppers (F. G. F.).*	*Peru Smooth (Good Fair).*	*Peru Rough (Good Fair).*	*Peruvian Afifi (Good Fair)*	*Brazilian Pernam (Fair).*	*West African (Middling).*	*East African (Good Fair).*	*Indian No. 1 Good (Oomra).*	*Percentage of Indian on American.*
1923–24.									
August ..	16·75	15·78	17·00	15·75	15·03	14·78	13·50	10·15	*67*
September ..	17·60	17·86	17·50	16·75	17·36	16·86	15·75	11·05	*65*
October ..	18·05	19·03	17·50	17·25	18·53	17·72	16·25	11·85	*66*
November ..	24·65	23·87	21·00	25·00	22·27	21·62	21·00	15·60	*72*
December ..	23·30	23·17	22·00	23·50	21·57	20·92	20·75	15·10	*72*
January ..	21·00	21·86	23·00	22·50	20·26	19·61	19·50	14·00	*71*
February ..	20·10	19·48	22·50	21·25	17·88	17·23	17·80	12·35	*70*
March ..	20·10	18·26	22·00	20·00	16·66	16·01	16·65	11·50	*70*
April ..	23·25	20·15	22·25	21·75	18·15	17·65	18·70	12·25	*67*
May ..	24·00	20·64	22·50	22·00	18·64	18·13	19·50	12·75	*70*
June ..	23·20	19·18	22·50	22·00	17·43	16·93	18·35	11·80	*68*
July ..	24·45	20·34	22·50	21·50	18·59	18·09	18·45	12·30	*67*
1924–25.									
August ..	21·65	17·91	22·50	21·50	16·16	15·66	16·70	10·90	*69*
September ..	19·95	17·14	21·00	19·00	15·39	14·39	15·20	10·80	*77*
October ..	17·25	16·58	20·00	19·50	14·83	13·43	16·30	11·70	*86*
November ..	17·90	16·04	19·75	20·50	14·79	13·14	16·40	12·00	*88*
December ..	19·15	15·49	19·75	21·50	14·49	12·73	16·00	11·50	*87*
January ..	20·05	14·87	19·75	22·50	13·87	12·38	16·35	10·60	*82*
February ..	19·90	15·89	19·75	22·50	14·89	13·45	17·00	11·55	*83*
March ..	21·05	15·83	19·75	22·50	14·83	13·60	17·70	11·35	*82*
April ..	20·15	15·15	19·75	22·50	14·40	13·10	17·15	10·75	*81*
May ..	18·55	14·49	19·75	21·50	13·74	12·47	16·20	10·15	*78*
June ..	18·55	14·93	19·75	21·50	14·18	12·85	16·10	10·35	*77*
July ..	18·80	15·23	19·75	21·50	14·23	13·00	16·00	10·50	*78*
1925–26.									
August ..	17·90	14·40	20·00	21·00	13·15	12·50	15·40	10·05	*83*
September ..	18·15	14·61	22·00	20·00	13·36	12·61	15·45	10·55	*82*
October ..	16·20	12·50	21·00	18·75	11·00	10·25	13·15	8·65	*84*
November ..	16·15	12·04	21·00	17·50	11·19	10·44	13·40	8·65	*81*
December ..	14·15	12·52	21·00	16·00	10·77	10·04	13·05	8·00	*78*
January ..	13·85	12·73	21·00	16·75	10·98	10·28	13·20	8·05	*76*
February ..	13·30	12·33	19·00	16·00	10·58	9·88	12·75	7·60	*74*
March ..	12·30	11·91	16·00	14·00	10·41	9·71	12·35	7·20	*71*
April ..	12·20	11·59	16·00	13·00	10·09	9·44	11·75	7·20	*73*
May.. ..	12·60	12·13	15·00	13·00	10·63	9·98	12·20	7·60	*74*
June ..	12·05	11·41	15·00	12·75	9·66	9·31	11·55	6·80	*71*
July.. ..	12·20	11·92	14·00	12·25	10·17	9·77	11·60	7·50	*75*
1926–27.									
August ..	12·60	11·17	12·50	11·75	10·17	9·87	11·50	7·70	*76*

NOTES ON CURRENT LITERATURE

COTTON IN INDIA.

398. India. We have received a copy of the *Review of Agricultural Operations in India*, 1924-25. Cotton is referred to on pp. 11-23. During the year under review, the area under this crop rose to 26,465,000 acres, with a yield of 6,072,000 bales, as against 23,636,000 acres and 5,162,000 bales in the previous year. The average yield per acre was 92 lbs., as compared with 87 lbs. and 93 lbs. in the two preceding years. The quantity of raw cotton exported during the year ending March 31, 1925, was 3,326,000 bales of 400 lbs., as compared with 3,764,000 bales in the previous year. Indian cotton consumed by Indian mills was estimated at 2,050,891 bales, as against 1,798,215 bales in the previous year. The value of cotton goods exported was Rs. 11,27 lakhs. The work of the Indian Central Cotton Committee and of the Institute at Indore is described, and reference is also made to the research that is being carried out with a view to the production of improved seed.

399. Indian Science Congress, 1926. In the paper read by Mr. B. C. Burt, Secretary of the Indian Central Cotton Committee, at the joint discussion on "Some Modern Problems of Scientific Research for the Improvement of Cotton-Growing," a statement is included of the schemes financed by the Committee in the various provinces:

I. *Bombay.*—(1) *Gujerat:* Research on the physiology of the cotton plant, with special reference to the loss of crop caused by the shedding of bolls in black soil areas. (2) *Dharwar:* Research on cotton wilt, and plant-breeding work for the improvement of cottons of the Upland-American variety. (3) *Surat:* Investigations on the spotted boll worms (*Earias*, spp.) in Gujerat.

II. *Madras.*—Plant-breeding work on the *Herbaceum* cottons of the Westerns tract. Physiological and biochemical research scheme on (*a*) the reduction of the loss caused by the cotton stem weevil (*Pempheres affinis*) by the production of resistant strains, and including a study of the causes of susceptibility and resistance; (*b*) an investigation into bud, flower, and boll shedding.

III. *Punjab.*—Investigation into the cotton problems of the Punjab Canal Colonies, more particularly those connected with the growing of Punjab-American cotton, including the isolation and testing of pure types, the general physiological study of the growing of American cotton under canal irrigation, with special reference to the water requirements of the plant and the causes of the loss of crop by bud, flower, and boll shedding.

IV. *Central Provinces.*—Plant-breeding work for the production of cottons of improved staple for the Central Provinces and Berar. Cotton wilt investigation.

V. *United Provinces.*—Entomological research on the pink boll worm to determine the control measures necessary.

400. Present Position of Cotton, and the Unirrigated Tracts of the United Provinces. By Rama Prasada. (Printed by the Superintendent, Government Press, Allahabad, United Provinces.)

401. Indian Cotton Production. (*Text. Recorder*, xliv., **520**, 1926, p. 48.) A description of some of the activities of the Indian Central Cotton Committee, and the results achieved.

carried by stainers, and the attacks of boll worms. The bolls of American cotton are stated to be much more liable to shedding and damage, as the result of the attacks of stainers and boll worms, than those of the indigenous varieties. On the other hand, the indigenous cottons are more liable than the American varieties to damage from diseases not carried by insects. The investigations indicate that any hope of lessening the incidence of insect and fungus attack by control measures is neither great enough nor immediate enough to affect the question as to which variety of cotton should be adopted for the future. The solution of the problem would seem to lie in the evolution of a strain of indigenous cotton of long staple and of high export value. A strain of very high quality is needed, because in some years the yield per acre may be very low owing to the damage caused by insects, and it is only a high price per lb. which can make cotton a really attractive crop in those circumstances. Of the indigenous varieties tested, Ishan cotton would appear to be the most promising. The strains that have been bred by the botanist have very long lint of a very white colour; some have a high ginning percentage, and, what is rare in such cottons, a very strong lint. It is proposed that next season the Ishan selections should be multiplied as much as possible.

Northern Belt.—The total purchases of cotton for the season will probably amount to 37,000 bales, the prices paid being 2⅛d. to 2d. per lb. at railway stations, for first and second grades respectively, except during two or three weeks, when the prices at a few places were increased by ⅛d. per lb. There has been an increase in the production of American cotton of nearly 40 per cent. in spite of the fall in price last year, and the still lower price ruling this year. This is partly due to the extension of cotton cultivation, and partly to the more favourable weather conditions prevailing in important areas. Notwithstanding the lower price, there has been more competition in buying. The cost of animal transport has risen, and that of motor transport fallen, being definitely cheaper for distances up to 30 or 40 miles. Another Ibadan transport contractor took his lorries to Zaria, and all were fully employed, but there is still need for much further expansion of motor transport. The sealing of all bags of first grade seed cotton was introduced this season, and has proved a most valuable measure. Mud-walled markets have been built at most places by the Native Administrations, which are a great improvement on the matted enclosures used previously. The standard has been maintained at the markets, and the elimination of any subsequent substitution has probably caused a slight rise in the average grade of the exports.

Kano Province.—No substantial increase in cotton production has taken place during the year. In response to representations made by the Agricultural Department, the British Cotton Growing Association sent a buyer to work alternately at Daura and Kazaure on the market days. This has proved very helpful, and there is every reason to believe that it will result in increased production there next year. Seed transported on camels at Government expense has been distributed for next season from centres in the producing areas, instead of only at railway stations. It is proposed, if there is any prospect of buyers going to them, to open six or seven new markets out in the producing areas.

Niger, Ilorin, Oyo, and Abeokuta Provinces.—There has been no progress in cotton production in these Provinces, which is due partly to the lower prices ruling, and partly to the bad weather conditions.

412. NIGERIA. The *Fourth Annual Bulletin of the Dept. of Agric.*, August, 1925, contains some interesting and useful articles on cotton pests, etc. It also gives particulars of time of planting experiments, variety tests, manurial experiments and rotation experiments carried out at the Moor Plantation in 1924; variety tests at the Umuahia Experimental Farm, 1923-24; time of planting tests and rotation experiments at Ilorin, 1924; spacing tests, interplanting tests, early

green manuring experiment and ridging tests at Samuru, 1924; and the work carried out at the Mugana Seed Farm, 1924. Tables showing the details of the various experiments are included.

413. NYASALAND. *Cotton-Growing.* (*The Times*, "Trade and Eng. Supplmt.," April, 1926.) It has been suggested by Sir William Himbury, General Manager of the British Cotton Growing Association, that Nyasaland should eventually be able to grow 100,000 bales of cotton annually, but to achieve this result it is essential that the red boll worm should be kept in check, and the only practicable method of doing so is by the growth of rotation crops such as maize and millet.

414. RHODESIA (SOUTHERN). *Notice to Cotton Growers.* (*Rhod. Agr. Journ.*, xxiii., **5**, 1926, p. 449.) The following notice has been issued by the Dept. of Agriculture to cotton growers in Southern Rhodesia:

"In order to improve the existing supply of cotton seed, the Department of Agriculture proposes to examine as many cotton fields as possible during the present cotton-growing season, with a view to recommending selected fields as a possible source of seed for next season. Farmers who wish to have their cotton crops examined for approval are requested to communicate with the Secretary, Dept. of Agriculture, as early as possible, at the same time giving an undertaking that, in the event of their cotton crops being considered sufficiently good for seed purposes, they will be prepared to abide by the following conditions:

"1. All clean white seed cotton, free from stain, dirt, or trash of any kind, will be picked separately, and packed in wool packs suitably marked to indicate that the contents are to be specially ginned for seed.

"2. Such seed cotton to be ginned in the presence of the farmer himself who will make arrangements to see his cotton ginned, and the seed sewn up in clean bags, marked with the farmer's name or mark.

"3. In the event of the seed being finally approved, the owner will give an undertaking to sell it for not more than 3d. per lb.

"In addition to the examination in the field, the seed from selected crops will be finally examined at the ginnery by officers appointed by the Department of Agriculture, who will affix a seal on all bags which have been passed.

"In the event of the foregoing arrangements proving satisfactory, they will form a basis for the introduction of legislation in the matter of the sale of cotton seed for planting purposes in the future."

415. *Cotton Experiments.* (Abstr. from the *Rhod. Agr. Jour.*, xxiii., **7**, 1926, p. 576.) On May 25 farmers from all parts of the Colony visited the Cotton Breeding Station at Gatooma, where the methods of investigation employed were described in a short lecture by Mr. G. S. Cameron, Cotton Specialist of the Empire Cotton Growing Corporation, who also instructed those in attendance what to look for on the various plots to which they were afterwards conducted. The methods of laying out the plots for varietal testing were explained, showing how these must be repeated a number of times in order to arrive at the probable margin of error. Inspection of the plots revealed the fact that although the crop at the station is going to be a light one, due to a severe boll worm attack, the exotic varieties in the main varietal tests all showed to better advantage than Improved Bancroft. It is as yet too early to say which of the exotic varieties will eventually be selected as suitable for Rhodesian conditions, but there is good reason to believe that a superior variety to that at present being grown has been found.

416. SOUTH AFRICA. *Cotton Cultivation.* (*The Times*, "Trade and Eng. Supplement," April, 1926, p. 80.) It is stated in this article that cotton cultivation in South Africa presents almost incalculable possibilities, to which the Government and private interests are equally alive. There is an estimated potential acreage

of over 4,000,000 acres suitable for cotton, and in the opinion of Mr. P. Koch there is more potential wealth in the future cotton fields of South Africa than in the gold mines of the Witwatersrand. Already twenty-two registered ginneries have been erected in the Union and two in Swaziland. It is stated that cotton can be grown on nearly every type of soil where maize grows, provided it is deep and well drained, and most parts of the Union suitable for the growing of cotton are very well supplied with cheap labour. The cost works out at about £2 to £3 per acre, and the net profit at about £1 to £8 per acre. Much, of course, depends on the farmer and other variable circumstances, but it is already established indisputably that cotton is a more profitable crop than maize.

417. *Railways in South Africa.* The Railways and Harbours Board of South Africa, having been requested by the Government to consider a proposal for the extension of the Matubatuba-Pongola Railway from Wanhoop on the south bank of the Pongola River to a terminal point in the neighbourhood of the Swaziland border, a distance of approximately five miles, have recommended its construction at an estimated cost of £67,356. The Imperial Government has agreed, on behalf of the Swaziland Administration, to a contribution of £10,000 towards the cost of this extension. The rapid progress made recently in the development of the low veld flats north of the Pongola River and on adjacent portions of Swaziland, and the attention paid to this area by companies and individuals possessing the capital necessary for the rapid extension of cotton-growing, render it essential that such an outlet be provided if all development in this area is not to be stifled.

418. *The Cotton Industry in South Africa. How the Union Government is Helping.* By Pieter Koch. (*Afr. Land and Home Journ.*, vol. ii., **2**, 1926, p. 15.)

419. *Cotton Progress and Prospects in* 1926. In an interview given to the *Sun and Agr. J. of S. Afr.*, Mr. R. Ingram, Director and Manager of the Cotton and Tobacco Exporting Co., Ltd., Pretoria West, states that the cotton which is being produced this season is what the spinner wants, being of good lustre, although slightly short in staple owing to the past dry season. He makes an interesting comparison regarding the relative cost of transporting cotton and maize. Finally, he deals with the importance of developing the cotton cake industry for the threefold benefit of the cotton grower, the dairyman and stock breeder, and the cotton cake manufacturer.

420. SUDAN. In the *Afr. World*, Special Sudan Number, May, 1926, a valuable account is given of the Sudan, of the Sennar Dam and its construction, and of cotton-growing developments, gum collection, etc., which should be read by everyone interested.

421. *Cotton-Growing in the Sudan.* (Abstr. from *East Africa*, vol. ii., **86**, 1926, p. 737.) In an article to the *North American Review*, Mr. Pierre Crabites, Judge of the Cairo Mixed Tribunal, has some very straight facts to put before the American public, which, he thinks, has cause for real anxiety as an outcome of East African cotton-growing.

422. SWAZILAND. *Cotton-Growing in Swaziland.* Advices recently received from Mr. R. C. Wood, the Corporation's Cotton Specialist in Swaziland, state that although the season cannot, from its exceptional dryness, be called a good one for cotton, there is no doubt that the crop has stood the drought remarkably well, and has turned out a good deal better than was at one time thought. In general, it may be said that good farming has produced a fair crop, but on land insufficiently prepared or unintelligently cultivated, the crop has only been moderate. The yields may be expected to run from 300 lbs. to 750 lbs. of seed cotton to the acre. The first cotton reaching the ginnery was not of a very good quality, but it was hoped that later pickings would be better. Some of the more

progressive farmers were already cutting out this year's crop and sacrificing what appeared likely to be only a very small late picking, in order to keep down insect pests.

At headquarters various experiments have been carried out—*e.g.*, time of planting, spacing, and selection experiments, the latter with a view to evolving a jassid-resistant variety of cotton. Consideration is already being given to the supply of seed for next season, and arrangements will be made for germination tests on likely samples of seed arriving at the ginnery, and for the multiplication, as far as possible, of any supply of pedigree seed received from South Africa.

The Cotton Plantations, Ltd., have generously consented to erect a small laboratory and store-room on their North Ingwavuma Estate, and place land at the disposal of Mr. Wood for a small substation during the next season.

423. UGANDA. *Cotton-Growing in Uganda.* (Abstr. from *East Africa*, vol. ii., **94**, 1926, p. 894.) As a result of his recent tour in Uganda, Sir William Himbury, General Manager of the British Cotton Growing Association, is of opinion that the outlook for the future of cotton-growing in the Protectorate is good. There will be fluctuations in crops and prices, and although the climatic conditions this season have not been good—the possibilities being that the crop will not equal that of 1925—a steady increase in the future may be expected. Sir William considers that the policy to-day should be one of increasing the production per acre without increasing the acreage. He does not think it unreasonable to suggest that it is quite possible to increase the yield by 30 to 50 per cent. in most places without planting a single additional acre.

424. AUSTRALIA: NORTHERN AUSTRALIA AND ITS PLANTATION PROSPECTS. Based on the notes sent by Mr. A. O. Neville, Secretary for the North-West, Central Govt. Buildings, Perth, Western Australia. (Abstr. from *Trop. Life*, xxii., **4**, 1926, p. 13.) *Cotton:* With regard to cotton it is believed that this crop could be grown extensively in the northern areas, and as living conditions are not comparable with the full tropics, India, the Malay States, etc., it is considered that family or community settlement, backed with co-operative effort and organization, would probably enable the crop to be grown commercially with success. Present prices, however, are very low and prospects discouraging, and if this continues, it will make a big difference to cotton prospects in the northern areas. Up to the present the planting has only been on an experimental basis, but whatever cotton has been sent to Liverpool usually secured better prices than American middling quotations at the time.

425. QUEENSLAND. *The Evidence of Colonel Evans.* (Abstr. from *Queens. Agr. J.*, xxv., **4**, 1926, p. 396.) The Minister for Agriculture (Mr. W. Forgan Smith) has received a communication from Colonel Evans, M.A., C.I.E., late Director of Cotton Culture, setting out the principal matters that he had brought under the notice of the Tariff Board in connection with the cotton industry and the proposed bounty. Briefly, the views placed before the Board by Colonel Evans were as follows:

"1. That the establishment of the cotton-growing industry on a permanent basis depends on the capacity of the farmer to learn how to grow the crop properly, and that it is the duty of the Government to help to forward this end by means of experiment and practical demonstration. I explained fully what the Department had been doing in this direction.

"2. Until the grower had learnt how to grow cotton, financial assistance was necessary, especially in view of the low price of cotton.

"3. I pointed out that the 2d. bounty asked for was 50 per cent. above the total value of the cotton, and that if a *flat rate* without reservation was given, it would be quite possible for growers to grow inferior growths of cotton which could

not possibly pay when the bounty was lifted and the industry had to stand on its own feet.

"4. To this end I gave my opinion that a limit with regard to length of staple and grade should be laid down. This limit need not be too high, but it should be insisted that any cotton coming below the required standard of staple and grade should *not under any circumstances receive the bounty.*

"5. In order to keep up the quality also it will be necessary for the Department of Agriculture to have complete control of the seed.

"6. In order that the main object of the bounty should not be defeated, it will be better to make the announcement that the bounty should be on a scale gradually decreasing in value each year, the idea being that the grower should continue to learn how best to grow cotton, and not be content to merely plant cotton and to make no attempt to better his efforts. I pointed out that unless every endeavour was made by the grower to overcome some of these difficulties such as the high cost of picking, no progress will be made, and the industry might collapse if the bounty was suddenly removed.

"7. I made no suggestion with regard to the size of the bounty, but gave it as my opinion that financial assistance would be required for at least five years."

426. *Cotton Pool.* (*Queens. Agr. Journ.*, xxv., **4**, 1926, p. 394.) A Pool has been constituted for all seed cotton produced in Queensland after January 1, 1927, for a period of five years. The Board to administer this Pool will consist of seven representatives selected by the growers, and one member appointed by the Minister.

427. SAMOA: COTTON IN SAMOA. (Abstr. from *Int. Cot. Bull.*, iv., **3**, No. 15, 1926, p. 393.) Some successful cotton-growing experiments were carried on in Samoa during 1924. Samples grown were classified by the British Cotton Growing Association as fairly clear with a good colour, having a staple of full $1\frac{1}{8}$ inches, very strong, and inclined to be harsh. During 1925 additional quantities of seed were imported and distributed to numerous schools and villages. To foster the industry legislation was introduced to prevent the introduction of new pests, to keep control of the pests now present, and to guarantee a minimum price to the producers.

428. WEST INDIES. *Cotton in Grenada.* (*Rpt. of the Agr. Dpt. for* 1925, p. 5.) During the year under review the cotton crop yielded 3,252 cwt. of lint of the estimated value of £16,500. Indications are that the production for 1926 will exceed that of 1925, as a result of the rigid enforcement of Ordinance No. 7 of 1924, which provides for the control of the pink boll worm.

429. *Some Results with Cotton Cultivation.* (*Trop. Agriculture*, iii., **6**, 1926, p. 110.) In a recent experiment, the Imperial College Department of Agriculture found that 12 inches spacing with Sea Island cotton gave the best result of six spacings, the widest being 24 inches. The yield at 12 inches was 1,575 lbs. seed cotton per acre, that at 24 inches being 1,210 lbs., differences that are statistically significant.

430. *Cotton in St. Kitts-Nevis.* From the *Rpt. of the Dpt. of Agr.*, 1924-25, recently received, we learn that the total acreage planted to cotton in the season under review was 4,000 acres. In most districts germination was good, but the hurricane of August, 1924, destroyed 60 per cent. of the cotton crop of St. Kitts and completely ruined the late planted crop of Nevis. The two most serious pests of cotton during the season were the Cotton Worm (*Alabama argillacea*) and the Pink Boll Worm (*Pectinophora gossypiella*).

COTTON IN EGYPT.

431. Seasonal Variation in Salinity of Water of some Drains of the First Circle of Irrigation. By R. Aladjem. (*Bull. No. 66, Tech. and Sci. Serv.*, Min. of Agr., Egypt, 1926. Obtainable from Govt. Pubns. Off., Min. of Finance, Dawawin P.O., Cairo. Price P.T. 5.)

432. Egypt and the Cotton Crisis. By A. M. Psalti. (*Egyptian Gazette*, April 8, 1926, p. 4.) The quality of Egyptian cotton has deteriorated greatly in recent years, due chiefly, in the author's opinion, to the admixture of the best Sakel cotton with inferior strains. In consequence of this deterioration, American cotton is being used in the manufacture of commodities for which only the best Egyptian cotton has previously been used. The author is convinced that Egypt's reputation as a fine cotton-growing country can be regained, and a firm demand for her cotton re-established by (1) Government purchases of good seed from the large estates for selling to growers, as a guaranteed seed, at a reasonable price; (2) by growing only the Sakel variety in Lower Egypt, or if this be found impracticable, by growing the main commercial varieties in certain definite zones; (3) by allowing ginners to deal in one type of cotton only, if the cultivation of cotton varieties in Lower Egypt other than Sakel be not prohibited. Finally, the author urges closer co-operation between the officials of the Ministry of Agriculture and the individuals interested in the cotton industry.

433. Egyptian Cotton. Restriction of Acreage. (Abstr. from *Cotton*, xxxii., August 7, 1926, p. 4.) A Reuter's telegram from Cairo states that, according to a *communiqué* from the Ministry of Agriculture regarding the cotton crop, the area devoted to the growing of Sakellaridis is 9 per cent. less than last year. The expansion of the flower was not so good in most provinces of Lower Egypt as last year, the ravages of the boll worm have been more extensive, and more shrubs have withered. The inspectors have unanimously decided that it is necessary to promulgate a law limiting the area under the cultivation of cotton to one-third of the present area.

COTTON IN THE UNITED STATES.

434. Sixteen Bales of Cotton on Five Acres. (Abstr. from *Int. Cot. Bull.*, iv., **3**, No. 15, 1926, p. 358.) The winner of the competition, "More Cotton on Fewer Acres," organized by Mr. Victor H. Schoffelmayer, agricultural editor of the *Dallas Morning News* and the *Semi-Weekly Farm News*, was Mr. G. M. Adams, of Tyler, Smith County, Texas, with a record crop of 16 bales on 5 acres of unirrigated land. The winner, once a plumber, owns and cultivates a farm more than forty years old, which was presumed to have been "worn out," but which has been restored to fertility by intelligent fertilization and cultivation. The cotton was classified as strict middling of 1 inch and one-sixteenth staple, and not the short Half-and-Half variety, which, by the way, was the variety cultivated by the winner of the competition in the previous year.

435. New Staple Standards for Use in U.S.A. (Abstr. from *Int. Cot. Bull.*, iv., **4**, **16**, 1926, p. 538.) At a meeting held in Washington last July, under the auspices of the Secretary of Agriculture, it was decided to promulgate a new set of staple standards to represent seventeen different lengths of American Upland. These new standards will come into effect on August 1, 1926, and represent the following lengths:

$\frac{3}{4}$ inch.	$1\frac{1}{16}$ inches.	$1\frac{3}{16}$ inches.	$1\frac{5}{16}$ inches.
$\frac{7}{8}$,,	$1\frac{3}{32}$,,	$1\frac{7}{32}$,,	$1\frac{11}{32}$,,
$\frac{15}{16}$,,	$1\frac{1}{8}$,,	$1\frac{1}{4}$,,	$1\frac{3}{8}$,,
1 ,,	$1\frac{5}{32}$,,	$1\frac{5}{32}$,,	$1\frac{1}{2}$,,
$1\frac{1}{32}$ inches.			

436. STANDARDS FOR EXTRA WHITE COTTON. (*Int. Cot. Bull.*, iv., **3**, No. 15, 1926, p 358.) A Reuter message from Washington states that new standards for extra white cotton have now been established. The standards will become effective as from August 1, 1927, under the authority of the United States Cotton Standards Act. The establishment of the grades is in response to the needs of growers of extra white cotton, which usually commands a premium over other cotton. The standards are in five grades, ranging from No. 3 extra white to No. 7 extra white inclusive. The standards may be used as tentative or permissive standards in the purchase and sale of extra white cotton up to August 1, 1927, after which they will be compulsory.

437. TENDERABLE GRADES OF COTTON. (Abstr. from the *Text. Recorder*, xliv., **520**, 1926, p. 103.) Authorities in the cotton trade have represented to the U.S. Dept. of Agriculture that it is desirable to add to the sixteen tenderable grades provided under the Lever Act, as amended, three new grades—namely, Strict Low Middling Spotted, Strict Middling Grey, and Middling Grey. The Cotton Division, Bureau of Agricultural Economics, of the Department is giving serious consideration to this proposal, and since it is understood that there are not any objections to the addition it is probable that the appropriate order will be issued at an early date.

438. COTTON CULTIVATION IN U.S.A. By David R. Coker. (*Text. World*, 1926, **69**, 3115, etc., Abstr. from *Summ. of Curr. Lit.*, vi., **13**, 1926, E. 74.) Breeding experiments in the eastern States are described. New strains of Cleveland Big Boll, with a high yield of lint per acre and a staple of $1\frac{1}{16}$ to $1\frac{1}{8}$ inch, have been produced. The author urges the desirability of cultivating big bolled varieties, and the need of better methods of planting and a fairer system of direct buying from growers.

439. COTTON INVESTIGATIONS IN NORTH CAROLINA, 1923-24. By R. Y. Winters. (*N. Carolina Sta. Rpt.*, 1924, pp. 31-34. Abstr. in *Exp. Sta. Rec.*, vol. **53**, 8, 1925, p. 736.)

440. COTTON INDUSTRY IN THE U.S.A. BUSINESS CYCLES. By L. Bader. (*Text. World*, 1925, **68**, 2615-17. Abstr. in *J. Text. Inst.*, xvii., **6**, 1926, A. 166.) A general discussion.

COTTON IN FOREIGN COUNTRIES.

441. We have received from the Association Cotonnière Coloniale a copy of Bulletin No. 75.

442. COTTON CULTIVATION IN ALGERIA. (*Text. Recorder*, xliv., **520**, 1926, p. 47.)

443. COTTON CULTIVATION IN THE BELGIAN CONGO. (*De Textielindustrie*, 1925, **6**, 105-6. Abstr. in *Summ. of Curr. Lit.*, vi., **12**, 1926, E. 67.)

444. COTTON IN BRAZIL. (*Trop. Agriculture*, iii., **4**, 1926, p. 71.) The Brazilian Government has addressed itself to the cotton problem with considerable energy; several cotton-growing experiment stations have been established; improved seed is being distributed on a large scale; and very favourable conditions are provided for the establishment of new cotton plantations and the erection of gins. The cotton production is being concentrated in Sao Paulo, which now produces about a quarter of the total crop. There are fifty-five modern cotton mills in Sao Paulo; within little more than ten years Brazil's cotton imports have decreased almost to the vanishing-point; her more than 30,000,000 population is practically independent of foreign mills for all except the finer weaves, and exportation is growing.

445. Ceara Cotton Cultivation in Brazil. By B. G. C. Bolland. (*Int. Cot. Bull.*, 4, 1926, pp. 236-43.)

446. Cultivation of Acala Cotton in China. By Kuo, Tan Sien, *et al.* (*Bot. Abstr.*, 1926, 15, 488. Abstr. in *Summ. of Curr. Lit.*, vi., 12, 1926, E. 68.)

447. Cotton Possibilities in the Republic of Colombia. By A. S. Pearse. (*Text. Recorder*, vol. xliv., No. 519, 1926, p. 49.)

448. Cotton Cultivation in Dahomey. (*L'Avenir Text.*, 1925, 7, 12, p. 15. Abstr. in *J. of Text. Inst.*. xvii., 7, 1926, A. 160.)

449. Cotton Cultivation in Japan. By K. Ohara. (*Faserforschung*, 1926, 5, 157-8. Abstr. in *Summ. of Curr. Lit.*, vi., 12, 1926, E. 70.)

450. Peruvian Cotton. (Abstr. from *Int. Cot. Bull.*, iv., 3, No. 15, 1926, pp. 383-92.) Another report on the cultivation of cotton in Peru has been prepared by the U.S. Dept. of Agricultural Economics to supplement one issued by that Department in 1923 (*Bull.* 95, "The Cotton Industry in Peru"). The report contains much useful information regarding the varieties of cotton grown, production centres, climatic conditions, methods of cultivation, use of machinery, production costs, markets, etc.

451. The Deterioration of the Peruvian Tanguis Cotton. By J. H. Pardo (Abstr. from *Int. Cot. Bull.*, iv., 4, 16, 1926, pp. 485-8.) Deterioration seems to be going on like that of Sakel in Egypt, and similar measures, especially "one district one variety," are recommended.

452. Spain. We have received from the Dept. of Overseas Trade a copy of the *Report on the Industries and Commerce of Spain*, April, 1926. Cotton is dealt with on p. 51, special mention being made of the scheme for growing cotton near Seville.

453. Cotton Cultivation in Adana, Turkey. (*Int. Cot. Bull.*, 4, 1926, 247. Abstr. from *Summ. of Curr. Lit.*, vi., 7, 1926, E. 44.) Estimates of the possibilities in the Adana reach the figures of 2,000,000 acres annually, and the production of 1,500,000 bales. The deltas of the rivers Yoshil and Kizil Irmak in the Smyrna region are thought possible of growing a similar quantity. French interest and American capital and mechanical equipment are special features of the development. France is the chief consumer of Turkish cotton.

CULTIVATION AND MACHINERY ; IRRIGATION, ETC.

454. Elementary Cotton-Growing Lessons. By F. A. Merrill. (*U.S. Dpt. Agr. Misc. Circ.*, No. 43, 1925. Abstr. from *Summ. of Curr. Lit.*, vi., 10, 1926, E. 66.) A course of lessons for children residing in cotton-growing areas is designed to follow the seasonal activities and to familiarize the pupils with modern farming, grading, ginning, and marketing methods.

455. Special Problems of Cotton-Growing in Canal Colonies. By W. Roberts. (Paper read at the Indian Science Congress, 1926.) Deals briefly with the history of American cotton in the Púnjab, the yield per acre, varieties, marketing difficulties, seed supply, etc.

456. Sterilization of Cotton Seed. (*S. Afr. Cott. Growers' Jnl.*, ii., 8, 1926, p. 49.)

457. Cotton Seed Disinfection. By E. Ferreira. (*Chem. Abstr.*, 1925, 19, 3345. Abstr. from *Summ. of Curr. Lit.*, vi., 12, 1926, E. 71.) The author concludes from the results of tests in which he used 400 grams of carbon disulphide

per cu. m. of seed for twenty-four hours, that the carbon disulphide treatment in no way injures the germinative power of the seed. It prevents fermentation of weak seeds which, though they do not germinate, might cause the development of a harmful vegetation. Disinfection should be carried out a short time before sowing; the seed should be quite dry and quite ripe when disinfected. The method of determining germinative power is described.

458. THE EFFECT OF THE SHARAQI PERIOD UPON THE YIELD OF COTTON IN EGYPT. By E. McKenzie Taylor. (*Bull. No. 51, Tech. and Scientific Serv.*, Min. of Agr., Egypt. Obtainable from Govt. Publns. Office, Min. of Finance, Dawawin P.O., Cairo. Price P.T. 5.) An investigation of the effects of the *sharaqi*, or summer fallow, period upon the yield of cotton in Egypt has shown that the yield of cotton from land which has been subjected to a long summer fallow is considerably greater than that from land which has had a short summer fallow. The theory that the decline in the yield of Egyptian cotton is directly attributable to the fact that the *sharaqi* period has been almost entirely eliminated is confirmed. As this elimination of the *sharaqi* period is largely due to the early sowing of maize, the postponement of the sowing date of maize until about August 10 is suggested.

459. THE RISE OF THE SAW GIN. By G. S. Meloy. (Abstr. from *S. Afr. Cot. Growers' Jnl.*, vol. ii., 12, 1926, p. 7.) A discussion of the origin of the two types of ginning, and their advantages and disadvantages. It is pointed out that the continued use of the roller gin tends to select two extreme types of cotton with the common characteristic of easy detachment of the hairs. The saw gin—really a hook gin—gives the best results on the whole, a fact confirmed by recent observations in India (abstr. 469).

460. COTTON-OPENING MACHINERY. By H. Wilkinson. (*Text. Manufr. Jubilee No.*, 1925. Abstr. from *Summ. of Curr. Lit.*, vi., 1, 1926, F. 1.) A general review of fifty years' progress in cotton-opening machinery.

461. COTTON-COMBING MACHINERY. By W. J. Ellison. (*Text. Manufr. Jubilee No.*, 1925. Abstr. from *Summ. of Curr. Lit.*, vi., 1, 1926, F. 1.) An account of the development of cotton-combing machinery in the last fifty years.

462. In the *Rev. of Agr. Operations in India*, 1924-25, p. 68, it is stated that the Agricultural Engineer in the Central Provinces has designed two new implements—viz., a reversible blade *bakhar* and a grubber for clearing the land of sorghum and cotton stalks.

463. COTTON VARIETY EXPERIMENTS. By J. O. Ware. (*Arkansas Sta. Bull.* 197, 1925, pp. 3-27. Abstr. from *Exp. Sta. Rec.*, vol. 54, 1, 1926, pp. 33-4.) Under the test conditions, 14,000 or 15,000 plants per acre seemed to be the rate at which slight differences in plant numbers least affect yields.

Consideration of the agronomic data recorded indicated that, while early varieties have a somewhat lower gin turnout and smaller bolls, they average more lint cotton per acre during a period of years. The high lint percentage of the later varieties did not make up in lint for the extra amount of seed cotton produced by the early varieties. Gin turnout alone did not appear to be a safe criterion for a variety. Earliness seems necessary for high production under boll weevil conditions. On the average, total yields are proportional to the size of the first picking. Each year the early sorts have been certain and usually produced the highest yields, while, except in 1924, big boll later varieties generally yielded less, and almost failed in some instances. Long staple accompanies a lower lint percentage, but, as indicated by Express and Delfos, not necessarily low yield. Length and quality of lint appeared to be affected by soil and season.

464. Field Crops Experiments at the Georgia Coastal Plain Station, 1924. (*Ga. Coastal Plain Sta. Bull.* 5, 1925. Abstr. from *Exp. Sta. Rec.*, vol. 54, **2**, 1926, p. 131.) Wilt-resistant cotton varieties have produced the highest yields during four years, Petty Toole, Council Toole, Lewis 63, and Covington Toole proving good for infected lands Decided increases have accrued from the liberal use of potassium. A fertilizer containing from 8 to 10 per cent. of phosphoric acid, 2 to 3 per cent. of ammonia, and 5 to 6 per cent. of potash has given excellent results on the test soil, Tifton sandy loam. Rather liberal amount of fertilizers seemed desirable, 1,000 lbs. per acre giving profitable increases. Nitrogen applied at cotton-planting time should be derived from organic and inorganic sources in about equal amounts. The 1924 results indicated that from 100 to 125 lbs. of sodium nitrate or its equivalent in ammonium sulphate, or other quickly available nitrogenous fertilizer, applied as top-dressings or side applications to cotton will produce economical increases in yield. Liming did not appear to benefit cotton. Cotton is at present receiving the most benefit from a complete fertilizer in conjunction with a cover crop. Unthinned cotton has not produced as well as thinned cotton.

465. Preliminary Note on the Development of the Cotton Plant in the Gezira. By M. A. Bailey. (*Wellcome Trop. Res. Lab., Khartoum.* Abstr. from *Summ. of Curr. Lit.*, vi., **14**, 1926, E. 87.) Extreme dryness, frequent pickings, and constant winds give the plant a very unproductive appearance in April, which is belied by the actual yields. The plants are more normal in the early stages, but fruiting branches are not put out until the twelfth to the fourteenth node. Contrasted with Sakel in Egypt, seven potential fruiting branches are lost, and the crop is delayed by at least a fortnight. Legginess and defoliation are thought due to some other cause besides blackarm, for even plants from less affected Tokar seed also delayed flowering to the fifteenth node. Flowering curves from Egypt, the Sudan, and the West Indies are compared. They all commence to rise about two and a half months after sowing, and tend to arrive about six weeks later at a maximum, and then to fall away rapidly. If the curves start late they tend to fall correspondingly late, and if they rise slowly there is a tendency for them to remain high for a longer period, and to fall away more gradually. The maximum rate of flower production per day in the Sudan examples is, however, very low, and this deficiency is thought due to harmful factors operating in late August and September "when humidity is quite suitable," and not to the rapid fall in relative humidity in October. The plants appear to be suffering from lack of root space, though spacing is wider than is customary in Egypt.

466. Sudan: Field Demonstration at the Gezira Seed Farm. By H. C. Jefferys. It is estimated that, as a result of the varietal experiments now being carried out, from 80,000 to 100,000 lbs. of pure Sakel will be issued from the Seed Farm each year, and that the whole Gezira area of approximately 100,000 acres can be sown with the third generation of this seed. Where cotton plants on some of the experimental plots were attacked by blackarm, applications of sulphate of ammonia at the rate of about 175 lbs. per acre proved markedly beneficial. Contrasting Gezira seed from the 1924-25 crop (which was heavily infected with blackarm, the seed receiving no treatment) with Sakel, Tokar, and Kassala seed, the germination of the Gezira seed was decidedly inferior to the other three varieties, but after two months' growth the difference between the strains was not so apparent. Ashmouni and Zagora varieties appeared unsatisfactory.

467. Standard Methods of Analysis of Fertilizers. By J. Sen. (*Bull. No.* 164, 1926, *Agr. Res. Inst. Pusa.* Obtainable at Govt. of India Central Publication Branch, 8, Hastings St., Calcutta. Price As. 4, or 6d.)

468. Seasonal Variation in Salinity of Nile Water at Rodah (Giza), with Special Reference to Alkaline Carbonates. By R. Aladjem. (*Bull. No.* 69, *Tech. and Scientific Serv.*, Min. of Agr., Egypt. Obtainable from Govt. Publications Off., Min. of Finance, Dawawin P.O., Cairo. Price P.T. 5.)

469. Comparative Spinning Tests on Machine-ginned and Saw-ginned Cotton, Punjab-American Type 289F., carried out at the Technological Laboratory of the Indian Central Cotton Committee. The interesting general feature about the results of these tests is the marked superiority of the saw-ginned cotton over that ginned with the roller, the former being valued at Rs. 25 per candy more.

470. Cotton Grading. By T. Bühler. (*Leipziger Woch. Text. Ind.*, 1925, **40.** Abstr. from *Summ. of Curr. Lit.*, vi., **11,** 1926, L 18.) The author discusses the present methods of valuing raw cottons as employed by buyers, and points out their inaccuracies. He cites particularly cases in which a hand-stapled sample gave as many as three staple diagrams. He suggests the establishment of a European (or German) cotton testing-house, and urges the necessity for collecting and publishing comprehensive cotton statistics, independently of America.

DISEASES, PESTS, AND INJURIES, AND THEIR TREATMENT.

471. Boll Weevil in Cotton. By F. P. Mackie. (*Rpt. Bombay Bact. Lab.*, 1924, pp. 30-1. Abstr. from *Rev. App. Ent.*, xiv., Pt. 5, 1926, Ser. A, p. 233.) Tests have been made with hydrocyanic acid gas with a view to fumigating American cotton to prevent the introduction of the boll weevil (*Anthonomus grandis*, Boh.) into India. In the absence of this species various native weevils were used in these tests, including *Calendra*, which proved the most resistant. The time of exposure appeared to be of greater importance than the concentration of the gas; thus all individuals of this weevil were killed after exposure for nineteen hours or more to a concentration evolved from $\frac{1}{8}$ oz. each of sodium cyanide and sulphuric acid, whereas concentrations obtained with 1 oz. had no effect even after six hours. With formaldehyde vapour all the weevils were killed in four hours by a concentration of 10 parts per 100,000, or in two hours by 20 parts per 100,000. A few experiments to test the absorption of hydrocyanic acid by various substances indicate that liquid paraffin does not absorb the gas, but that cotton and kerosene do.

472. Boll Weevil Precautions. (Abstr. from *Int. Cot. Bull.*, iv., **3,** No. 15. 1926, p. 374.) In connection with the fumigation of imported American cotton with a view to avoid the entrance of the boll weevil into India, the Government has provided two barges, each capable of carrying 200 bales of cotton, and being rendered gas-tight by means of fabric hatch covers. With the approval of the Government the Bombay Port Trustees have undertaken to provide a further six barges with an aggregate capacity of 1,200 bales capable of being rendered gas-tight, and in addition lighters sufficient for 1,600 bales. Thus the gross fleet capacity, as at present arranged, is 3,200 bales. The strength of this fleet was arrived at by the Government, in consultation with the Port Trustees, the importations of the last few years being taken as a basis for what must be a speculative estimate.

473. Starving the Boll Weevil. (*Text. Recorder*, xliv., **520,** 1926, p. 103.) It is suggested by Sir J. C. Bose that the boll weevil might be starved out of existence. He stated that although the weevil is present all the year round, it only becomes dangerous to cotton when the bolls are formed and rains have made the plant so full of foliage that the insect can avoid being scorched to death on

hot sunny days. If the crop could be hastened, say, by a month, it could be gathered before the weevil was sufficiently developed to devour it, and that would mean an enormous saving.

474. EARLY SUMMER DISPERSION OF THE BOLL WEEVIL. By D. Isely. (*Res. Paper*, No. 32. *Journal Series, Univ. of Arkansas*. Abstr. in *J. of Econ. Ent.*, vol. xix., 1, 1926, p. 108.)

475. PROGRESS IN COTTON BOLL WEEVIL CONTROL. By W. E. Hinds. (Abstr. in *J. of Econ. Ent.*, xix., 1, 1926, p. 108.)

476. A NEW COTTON WEEVIL FROM PERU (EULECHRIOPS GOSSYPII). By H. S. Barber. (*Proc. Ent. Soc. Wash.*, xxviii., **3**, 1926, pp. 53-4. Abstr. in *Rev. App. Ent.*, xiv., Pt. 6, 1926, Ser. A., p. 251.)

477. THURBERIA WEEVIL IN SOUTH-WEST COTTON AREA. (Abstr. from *Text. Recorder*, vol. xliv., No. 519, p. 100.) The Thurberia weevil, a native variety of the common boll weevil of cotton, normally infesting the Thurberia plant in the mountains of Southern Arizona, has become more or less established, as determined by Dept. of Agriculture inspectors, in the cotton area along the Santa Cruz River in Arizona. Biological investigations of this weevil indicate that it may become as injurious in Western cotton areas as is the ordinary boll weevil in the main Cotton Belt from Central Texas eastwards.

478. COTTON SEED. EFFECT OF HEAT. By M. E. Woodbridge and R. E. McDonald. (*Bot. Abstr.*, 1926, **15**, 367. Abstr. from *Summ. of Curr. Lit.*, vi., **8**, 1926, A. 20.) Extensive experiments to determine the safety zone to which cotton seed might be heated to kill the pink boll worm without injuring the germination of the seed showed that cotton seed possesses great resistance to heat. With dry heat on dry seed the point of injury came between 72° and 83° C. for short exposures, and for two and three-hour periods between 70° and 74° C. The germinative power of the seed decreased as the temperatures and periods of exposure were increased, also the margin between the thermal death point of the pink boll worm and the temperature at which the viability of cotton seed became injured is large enough to be safe and to make sterilization of seed by heating a practical proposition.

479. ENTOMOLOGICAL NOTES. By D. S. Wilkinson. (*Cyprus Agr. Journ.*, xxi., Pt. 2, 1926, p. 47.) In the experimental cotton cultivation plots at Perivolia, which are being run with the idea of determining the variety of cotton most suitable for Cyprus, having regard to early production as a means of combating the attacks of the boll worms, *Earias insulana*, Bois., and *Platyedra gossypiella*, Saund., it was found, at the end of last season, that for the earlier producing varieties tested, such as Triumph, a percentage as high as 33⅓ of the bolls were attacked or otherwise in a diseased condition, due to insect attack.

480. THE COTTON BOLL WORMS OF SOUTHERN NIGERIA. By A. W. J. Pomeroy. (*Fourth Ann. Bull. of the Agr. Dpt., Nigeria*, August, 1925, pp. 107-8. The most important results of this season's biological experiments with regard to boll worms in Southern Nigeria may be summarized as follows:

Argyroploce leucotreta, Meyr. is undoubtedly a very serious pest of cotton in certain areas in Southern Nigeria and, owing to the number of probable food plants and its general habits, very considerable research is necessary before an effective control method can be devised. The most effective control at present seems to be the egg parasite.

Two forms of *Earias*, *luteolaria* and *citrina*, hitherto considered to be two species, have been proved to be forms of one species, *E. biplaga*, with the result that only two species of *Earias* appear to be of serious economic importance to the

cotton crop, *E. biplaga* and *E. insulana*. Two other distinct species, *E. ogorana*, Holl., and one at present undetermined, have been obtained on a single occasion at artificial light, but have not been bred from a very large number of larvæ taken from cotton in the field. *Earias* is controlled to a considerable extent by Hymenopterous parasites, and by certain species of predatory wasps.

Diparopsis castanea seems to depend entirely on cotton for its food supply, but its means of existence are largely augmented by the long duration of the pupal stage. The immediate cultivation and hoeing of the land on which cotton has been grown should prove a very effective control, as large numbers of pupæ would be destroyed by so doing.

Mussidia nigrivenella and other species with similar habits, at present regarded as scavengers rather than as a cause of primary damage, should be carefully watched for any indication that they are acquiring the habit of infesting green bolls.

481. Observations on the Extent of the Damage caused by Boll Worms and Stainers to the Cotton Crop in Southern Nigeria. By A. W. J. Pomeroy and O. B. Lean. (Abstr. from *Fourth Ann. Bull. of Agr. Dpt., Nigeria*, 1925, August, p. 58.) Two types of cotton were studied from an entomological standpoint in three different climatic zones, with additional observations as to the effect of different times of planting in the Intermediate zone. Bud shedding seemed to be of little importance, especially on the American variety. Boll shedding was not caused primarily by insect attack, at all events on the American cotton, and probably to only a small extent on the Native.

There seemed to be no fundamental difference with regard to actual damage caused by insects in the Forest and Savannah areas. In the Intermediate zone, situated within a "close season" area, there was no marked decrease in the bug attack, but the control measures appear to have had an appreciable effect in diminishing the boll worm attack.

The proportion of stained to clean cotton was greater on the early and late than on the July sown cottons, in the case of both varieties.

482. Investigations on Insects injurious to Agriculture in Brazil [Unters. an Landwirtsch. schadl. Insekten in Brasilien]. By K. Guenther. (*Zeitschr. angew. Ent.*, xi., No. 3, pp. 100-11, Berlin, December, 1925. Abstr. from *Rev. App. Ent.*, vol. xiv., Ser. A, Pt. 3, March, 1926, p. 130.) The Lygaeid, *Oxycarenus hyalinipennis*, and the pink boll worm, *Platyedra (Gelechia) gossypiella*, are both common on cotton bolls in the States of Pernambuco and Parahyba. In the case of the latter an average of seventy eggs per female was obtained in breeding cages. Incubation lasted five to ten days, and the larvæ at once bored into cotton bolls. The larval stage lasted an average of twelve days, and the pupal ten. Moths were constantly emerging, and ovipositing from July to October, when the author was breeding them, so that the destruction of the eggs by spraying would necessitate the application of an insecticide every three days, and this is not feasible in Brazil. When the larva is feeding on the seed, the boll bursts, and its contents turn to a black, powdery substance that is attractive to other insects, such as the caterpillars of *Pyroderces rileyi* and a Phorid fly. These insects are beneficial rather than harmful, as they cause the boll worm, which often pupates in the burst boll, to be exposed to the attacks of birds, etc. In captivity the adult moths lived fourteen days, but their life is probably longer in nature. The author rarely noticed the larval resting-stage in the field, but it occurred in captivity, thus supporting Willcocks' view that it is due to insufficient food and consequent failure to acquire the fat needed for metamorphosis.

483. Studies of the Pink Boll Worm in Mexico. By W. Ohlendorf. (*U.S. Dpt. of Agr. Bull.* 1374, Washington, D.C., 1926. Abstr. from *Rev. App. Ent.*,

xiv., 6, Ser. A., 1926, p. 295.) The average annual loss due to *Platyedra* (*Pectinophora*) *gossypiella*, Saund. (pink boll worm) in Mexico is now estimated at 20 to 25 per cent. of the cotton crop, both the quantity and quality of the lint and seed being reduced. All late bolls are so heavily infested as to be practically valueless, and although the mortality of resting larvæ in the field during winter and early spring is great, hardly any surviving if the fields are flooded during winter, the enormous numbers of larvæ that hibernate in stored seed and in the bolls and soil in the field ensure the presence of sufficient adults to begin the infestation in the following spring. The attacks of parasites have been spasmodic, and have not as yet proved of any importance. The survival of larvæ during the winter is much greater in bolls on stalks in the field than in bolls on the surface of the soil, showing the advantage of cutting and burning old stalks. The heat method of treatment of the seed is recommended (exposure to 115° F. for $3\frac{1}{2}$ minutes), while by the injection of live steam into the seed mass the time of exposure can be lessened. The infestation of green bolls was reduced by as much as 60 per cent. by repeated application of arsenical dusts in the field, and this method of control seems very promising, but requires further testing.

484. PINK BOLL WORM IN TEXAS. (*Qtrly. Bull. State Plant Bd. Miss.*, v., **4**, 1926, pp. 1-3. Abstr. from *Rev. App. Ent.*, xiv., **6**, Ser. A., 1926, p. 294.) This pest has recently been found hibernating in cocoons in the ground, where it can withstand frost, snow, and other unfavourable conditions. This may, to a certain extent, explain the heavy infestation in fields that were carefully cleaned up the year before. The suggestion of a non-cotton zone 300 to 500 miles wide, starting five miles east of the Rio Grande and extending to the western limits of dry farming, is being submitted to the Pink Boll Worm Commission of Texas during 1926, with a view to putting it into operation in the following year. In the meantime, regulated zones will be created, restricting the movement of cotton products. Strict quarantines are being maintained in Mississippi against the importation of any dangerous material from infested States, and every precaution is being taken to ensure the immediate recognition of the pest.

485. A BOLL WORM INFESTING GOSSYPIUM DAVIDSONII IN SONORA, MEXICO. By A. W. Morrill. (*J. of Econ. Ent.*, vol. 19, **3**, 1926, p. 572.)

486. COTTON STAINER, U.S.A. (TEXAS), LIFE HISTORY. By T. C. Barber. (*J. Agr. Res.*, 1925, **31**, 1137-47. Abstr. from *Summ. of Curr. Lit.*, vi., **8**, 1926, E. 51.) *Dysdercus obscuratus* has been found in cotton fields in Texas. It occurs from Central America along the Gulf Coast to the lower Rio Grande Valley of Texas, the area of infestation probably being extended by flight. The species feeds on *Sida carpinifolia*, *Ambrosia artemisiæfolia* and *elatior*, and *Verbesina encelioides*. The eggs are deposited usually under the surface of the ground. The incubation period is about five days in midsummer. The nymph has five stages. In the Rio Grande Valley the average period of development from egg deposition to adult was found to be 32 days in midsummer, 55 days in autumn, and 87 to 108 days in winter. The adults are found commonly in groups on the plants on which they feed; the groups move from plant to plant.

487. COTTON STAINERS AND CERTAIN OTHER SAP-FEEDING INSECT PESTS OF THE COTTON PLANT. By E. Philpott Mumford. A preliminary enquiry into the effect of climatic and soil conditions upon the incidence of these pests, with a valuable bibliography.

488. A STATISTICAL SURVEY OF THE INFESTATION OF DYSDERCUS SPP. ON COTTON IN NIGERIA. By F. D. Golding. (*Fourth Ann. Bull. of Agr. Dpt.*, Nigeria, August, 1925, p. 80.) *Dysdercus* was almost completely absent from cotton at Samaru and Bomo, near Zaria, probably as a result of excessive aridity. Migra-

tion to the cotton commenced earlier at Ilorin than at Ibadan; stainers were more numerous at the latter station, and did not diminish in numbers so rapidly in January.

The main migration to cotton at Ibadan commenced in the week during which the maximum number of Allen flowers was produced, and is thought to have been induced in response to the attraction exerted by this heavy flowering. There were two phases in the migration to Moor Plantation cotton, the first consisting of a gradual influx, mainly composed of one form of *D. superstitiosus*, commencing in August, and the second of a sudden infestation by another form of that species and *D. melanoderes* beginning in the second week of October.

From an entomological viewpoint, the planting of contiguous plots of exotic cotton sown on different dates is an unsatisfactory method of testing the suitability of various dates of sowing, as the late sown cotton is subjected to a heavy attack by adults (of the first filial generation) bred on the earlier sown plots, two weeks after the peak of flowering and before any bolls have become mature. The infestation is heavier the later the cotton is sown.

Allen cotton is subjected to a much greater infestation of *Dysdercus* than is either of the indigenous varieties, Meko and Ishan. An augmented infestation occurred on Meko cotton interposed between Allen plots. The Allen plants were severely attacked by rhizophagous beetle larvæ, and it is doubtful whether, under more normal conditions, the increase in infestation would be sufficient to render variety tests, in which contiguous plots of exotic and indigenous cotton are utilized, unreliable.

A diminution in the breeding activity of Tachinid parasites of *Dysdercus*, and in the numbers of Reduviid predators coincided with an increase in the evaporating power of the air and the cessation of precipitation.

489. Cotton Aphis (Aphis gossypii, Glov.). (*38th Ann. Rpt. Texas Agr. Exp. Sta.*, 1924-25, pp. 19-24. Abstr. from *Rev. App. Ent.*, xiv., Pt. 6, 1926, Ser. A., p. 275.) In investigating the causes of the production of winged forms in the cotton aphis, it was found that, although starvation is an important factor, it is not the only one. Temperature and the age of the plants do not appear to be factors, nor is there any tendency for winged forms to appear in alternate generations. During the last year winged forms appeared in numbers whenever the aphids were crowded, and in these circumstances 50 per cent. would often be winged.

490. Entomology. (*38th Ann. Rpt. Texas Agr. Exp. Sta.*, 1924-25, pp. 19-21. Abstr. from *Rev. App. Ent.*, xiv., Pt. 6, 1926, Ser. A., p. 275.) Deals with the cotton aphis (*Aphis gossypii*), the boll weevil, and the cotton hopper (*Psallus seriatus*, Reut.). The latter insect appears to be an important factor in producing blasting of minute cotton squares. The most successful treatment was sulphur-naphthalene dust, which killed 92 per cent. of the immature stages, and fine sulphur, which killed 85 per cent. None of the dusts killed the adults.

491. Aspergillus Decay of Cotton Bolls. By M. Shapovalov. (Abstr. from *Rev. App. Mycol.*, v., 7, 1926, p. 425.) During the past few years a decay of cotton bolls, beginning as a soft, pinkish rot, and finally causing the desiccation of the boll, has been prevalent in the south-western States. Affected bolls become filled and covered on the outside with black masses of spores resembling those of smut—the name by which the disease is incorrectly known in California. The causal organism is *Aspergillus niger*, which is sometimes associated with insect injuries. Successful inoculations have been made, under field and laboratory conditions (76 and 100 per cent. infection, respectively), by the insertion of spores in scalpel stabs or needle pricks.

492. THE BORER IN THE ROOTS OF THE COTTON PLANT. (Translated.) By G. Bondar. (*Correio-Agric.*, iii., No. 9, 1925, pp. 241-8. Abstr. from *Rev. App. Ent.*, xiv., Pt. 5, 1926, Ser. A., pp. 238-9.) The weevil, *Gasterocercodes gossypii*, Pierce, is a native of South America, and occurs throughout Brazil, where it has infested cotton for many years. Its larva bores into the roots and underground parts of the stem. In 1925 the weevil was injurious to cotton in Bahia, and was also found in *Hibiscus esculentus*, its original food plants appearing to be some other Malvaceæ such as *Stylosanthes* and *Gossypium brasiliense*. It requires about two months to complete its life-cycle. The control measures advocated consist in burning the wild food-plants named before establishing a new cotton plantation. In existing cotton fields it is necessary, in infested districts, to root up and burn all the old cotton plants after the harvest.

493. ON THE DISTRIBUTION AND HOST PLANTS OF THE COTTON FLEA-HOPPER (PSALLUS SERIATUS, Reuter) HEMIPTERA, MIRIDÆ. By H. H. Knight. (*J. Econ. Ent.*, xix., 1, pp. 106-8. Abstr. from *Rev. App. Ent.*, xiv., Pt. 6, 1926, Ser. A., p. 266.) The author has discovered that the natural food-plants of the Capsid, *Psallus seriatus*, Reuter, which has recently been recorded as injuring cotton in Texas and other southern States, are various species of *Croton*, especially *C. texensis*. A description of the adult is given, and its distribution in the United States is discussed.

494. OBSERVATIONS ON SYAGRUS CALCARATUS, F. AND HELOPELTIS BERGROTHI, REUT., MINOR PESTS OF COTTON IN SOUTHERN NIGERIA. By F. D. Golding. (Abstr. from *Fourth Ann. Bull. of Agr. Dpt.*, Nigeria, August, 1925, p. 88.) The rhizophagous larvæ of *Syagrus calcaratus*, F. were responsible for the death of a considerable number of May and June sown Allen plants, but cotton sown in the middle of July was comparatively immune. Native cotton was attacked by larvæ of *S. calcaratus*, but has a greater power of recuperation than has the introduced cotton.

Moist soil conditions are required by *S. calcaratus* larvæ, and it is probable that the amount of rainfall in July and August is intimately connected with the prevalence of this pest.

Helopeltis bergrothi, Reut., hitherto unrecognized as a cotton pest in Nigeria, has been found to attack the stems, leaves, bolls, and buds of the cotton plant. When the main stem is attacked, the terminal shoot dies; and although the attacked plant usually recovers bud production is retarded. *Helopeltis* damage was greater on Native than on exotic cotton; of the Native cottons *G. vitifolium* suffered more severely than *G. peruvianum*.

495. SECOND REPORT OF THE TSETSE-FLY INVESTIGATION IN THE NORTHERN PROVINCES OF NIGERIA. By Llewellyn Lloyd *et al.* (Abstr. from *Bull. of Ent. Res.*, vol. xv., 1, 1924, pp. 1-26.) This report contains a record of the trypanosome infections, food and breeding of *G. morsitans* and *G. tachinoides* obtained by examining the flies at various foci over a period of fourteen months.

496. SOUTHERN RHODESIA. *Tsetse-Fly in the Lomagundi District.* By R. W. Jack. (*Rhod. Agr. Journ.*, xxii., **6**, 1925, p. 634, and xxiii., **3**, 1926, p. 257.) An account of operations carried out with a view to interposing a barrier of country unsuitable to tsetse-fly between the occupied farms and the definite fly area, through which it is hoped the insects will not penetrate.

497. SOME TROPICAL COPEOGNATHA, ESPECIALLY FROM THE FIJI ISLANDS. By H. H. Karny. (*Bull. Ent. Res.*, xvi., January, 1926, Pt. 3, pp. 285-90. Abstr. from *Rev. App. Ent.*, xiv., Ser. A., March, 1926, Pt. 3, p. 103.) The species dealt with include *Pseudocæcilius marshalli*, sp.n. from Fiji on young cotton.

498. A NEW SPECIES OF TRIPHLEPS (HETEROPTERA, ANTHOCORIDÆ) PREYING ON THE EGGS OF HELIOTHIS OBSOLETA, H.S. IN QUEENSLAND. By W. E. China. (*Bull. Ent. Res.*, xvi., Pt. 4, pp. 361-2, 1926. Abstr. from *Rev. App. Ent.*, xiv., Pt. 5, 1926, Ser. A., p. 226.) *Triphleps australis*, sp.n. predacious on the eggs of *Heliothis obsoleta*, F. in Queensland, is the first species of this genus to be recorded from Australia.

499. THE CHINESE COTTON GEOMETRID (BOARMIA SP.) By F. C. Woo. (Abstr. from *J. Econ. Ent.*, vol. **19**, 2, 1926, p. 413.) A native Chinese species which has become, since 1918, a serious pest of cotton in China.

500. REDUCTION OF THE LOSS IN COTTON CAUSED BY INSECTS. By M. A. Husain. (Paper read at the Indian Science Congress, 1926.) Describes the following three methods of control suggested for cotton pests in India, where, so far, seventy different species of insects alone are known to gain subsistence from the cotton crop—(1) Bringing about conditions which are unfavourable to insect life; (2) producing plants which can resist insect attacks either through inherent immunity or " healthy " development as a result of proper cultivation; (3) utilizing insect response for capturing them.

501. SOME BIOLOGICAL METHODS OF INSECT PEST CONTROL. (*Digest of Operations of the Dept. of Agr., Madras*, July, 1925.) A discussion of the method of control of insect pests by the utilization of their natural enemies, encouraging the growth of these, and when necessary introducing them from other countries. So far back as the older Pliny insects seem to have been classified into two divisions: *Coccinellids*, whose motto might be (in the words of Sir Arthur Shipley) "je mange," and *Coccids*, whose motto might be "je suis mangé." The article will repay reading.

502. PRELIMINARY LIST OF PLANT DISEASES RECORDED IN SOUTHERN RHODESIA. By F. Eyles. (Abstr. from *Rhod. Agr. Jour.*, xxiii., 7, 1926, p. 629.) A brief description is included of the following diseases attacking cotton in Southern Rhodesia, with a short note on the control measures suggested: Angular Spot, Anthracnose, Blackarm, Black Rust, Boll Drop, Boll Rot, Leaf Mottle, and Stem Wilt.

503. MANUAL FOR COTTON CULTIVATION IN THE ARGENTINE REPUBLIC. By N. E. Winters. (*Min. Agric. Nac.* [Buenos Aires] *Secc. Prop. e Inform. Circ.*, 539, 1925. Abstr. from *Rev. App. Mycol.*, v., Pt. 3, March, 1926, p. 161.) Anthracnose (*Glomerella gossypii*), bacterial blight (*Bacterium malvacearum*), cotton wilt (*Fusarium vasinfectum*), and sore shin (*Rhizoctonia* [*solani*]) are said to be more or less common on cotton in the Argentine Republic. Methods of control are suggested in each case.

504. COTTON PLANT DISEASES. BURMA. By D. Rhind. (*Ann. Rpt. of Mycologist, Burma*, for the year ended June 30, 1925. Abstr. from *Summ. of Curr. Lit.*, vi., **14**, 1926, E. 91.) Wilt was the only cotton disease reported during the year, the Wagale variety being chiefly affected. A selection from Wagale, however, has been found more resistant to wilt than most Indian cottons. A species of *Fusarium* resembling *F. vasinfectum* has been isolated from diseased plants in several localities.

505. COTTON EXPERIMENTS, 1925. By E. B. Ferris. (*Miss. Agr. Exp. Sta. Circ.*, 63, 1925. Abstr. from *Rev. App. Mycol.*, v., **7**, 1926, p. 426.) The following reference in this report is of phytopathological interest. Four out of fifty-six cotton plots used in fertilizer tests since 1919 having become infected by wilt (*Fusarium vasinfectum*), kainit (300 lbs. per acre) was added to the usual fertilizer, consisting of acid phosphate and nitrate of soda (300 lbs. per acre of each), on half the rows of each plot, to test its influence on the disease. Nearly all the

cotton died on the parts without kainit, while on those receiving it a considerable number survived. The yield from the plots receiving kainit amounted to 828 lbs. per acre, compared with 488 lbs from those not treated.

506. COTTON WILT STUDIES. By V. H. Young. (Abstr. from *Rev. App. Mycol.*, v., 7, 1926, p. 425.) Isolations of *Fusarium vasinfectum* from several parts of the United States showed an appreciable difference in their pathogenicity for cotton, and appeared to be distinct strains. Inoculations with a monospore strain in the greenhouse in late summer, and in soil temperature tanks at 30° C., gave 50 per cent. infection under the latter condition and none under the former. Experiments in the tanks at 22·5° to 35° resulted in no infection at 25°, some at 27·5°, and the highest incidence at 32·5°, while a trace was observed at 35°. A second experiment gave similar results.

507. COTTON WILT DISEASE. DESCRIPTION. By N. G. Zaprometoff. (*Rev. App. Mycol.*, 1926, **5**, 175. Abstr. from *Summ. of Curr. Lit.*, vi., **8**, 1926, E. 53.) Cotton seedlings suffer from a wilt attributed to *Nectriella vasinfecta*, the mycelium of which clogs the vascular bundles and interferes with the water supply of the plant. Generally the infected seedlings show a swelling at the base of the stem, together with an oblong brown canker which in wet weather turns pink. Inside the host tissue the fungus produces hyaline unicellular microconidia, and on the surface of the dead tissue, three to five-celled macroconidia of the *Fusarium* type. Chlamydospores are also occasionally produced. The perithecia of the fungus are found on the roots and underground portions of the stem.

508. BEHAVIOUR OF COTTON ROOT ROT AT GREENVILLE, TEXAS, INCLUDING AN EXPERIMENT WITH CLEAN FALLOWS. By H. C. McNamara. (*Jour. Agr. Res.*, xxxii., **1**, 1926, pp. 17-24. Abstr. from *Rev. App. Mycol.*, vol. v., Pt. 6, 1926, pp. 361-2.) A preliminary report of the observations made from 1919 to 1924 at the Cotton Breeding Field Station at Greenville, Texas, regarding the annual spread of the cotton root rot disease, *Phymatotrichum* (*Ozonium*) *omnivorum*. Each year the infested areas were carefully mapped to show the distribution of the disease in each cotton row, as indicated by plants that died before the setting in of frosts. The records show that during the period from 1921 to 1924 the disease advanced quite regularly, and suggest that the annual spread was approximately equal to the width of the annual border ring, averaging about 10 feet, the appearance of which was, however, much more distinct in some seasons than in others. Inside the border ring of dead plants there may occur a distinct zone where many of the plants, or even a majority, may survive, this inner ring roughly corresponding to the outer zone of the previous year, where all the plants had died. In general, the direction of spread appeared to be outward. The results of an experiment in which two heavily infected plots were kept free from all plants, the first for one year and the second for two years, indicated that an absolutely clean fallow during two years may prove to be a means of control of the disease, as the second plot showed no dead plants or evidence of root rot on being replanted with cotton after the fallow. The first plot, which showed dead plants on 64·4 per cent. of its surface in 1921, had its infected area reduced to 21·6 per cent. in 1923, after the one-year fallow, this figure being further reduced to 17·4 per cent. in 1924, the second year after the fallow.

509. COTTON DISEASES. By J. Costantin. (*Agron. Colon.*, **11** [1924], No. 79, pp. 1-6. Abstr. from *Exp. Sta. Rec.*, vol. **54**, 5, 1926, p. 449.) Deals with the Texas cotton root rot disease.

510. TEXAS ROOT ROT DISEASE. (*Texas Sta. Rpt.*, 1923, pp. 19-21. Abstr. from *Exp. Sta. Rec.*, vol. 54, **4**, 1926, p. 346.) The results of seven years' experimentation and observation on Texas root rot of cotton are given. The disease has been definitely proved through artificial inoculations to be caused by *Phymatotrichum omnivorum*.

511. Cotton Root Rot in Arizona. Experiments. By C. J King and H. F. Loomis. (*J. Agr. Res.*, 1926, **32**, 297-310. Abstr. from *J. Text. Inst.*, xvii., **6**, 1926, A.137.) Root rot caused by the fungus *Phymatotrichum omnivorum* causes a serious disease of cotton and the economic plants in Southern Arizona. Preventive measures found successful in Texas cannot be applied in Arizona, owing to the continued growth of the cotton plants until winter months. Experiments covering a period of four years were conducted in which the effects of farmyard manure and other organic materials were tested. In manured rows the incidence of the disease was considerably delayed, and as a result many plants which had partially decayed roots produced a full crop. It is suggested that, although the fungus may be little affected by this application of organic substances, the plants themselves, as a result of the treatment, are more able to resist the attacks of the disease organism.

512. Black Arm Disease of Cotton in Madras. (*Digest of the Operations of the Dpt. of Agr., Madras,* February, 1926, p. 3.) This disease causes the branches of the cotton, and sometimes the whole plant, to wilt and turn black as though it had been burned. It has been particularly severe this year on the Agricultural Experimental Station at Hagari, and has there caused damage amounting to 25 per cent. It is hoped next year to restore, at any rate partially, the old Bacteriological Section, and to make a special study of this disease to see if some remedy can be found for it.

Another cotton disease, which had a tendency to develop during the spell of wet weather in January, was a boll rot caused by a fungus known to scientists as *Vermicularia.* The drier conditions experienced later, however, reduced it.

513. Blackarm Disease of Cotton, with Special Reference to its Epidemiology in the Sudan. By R. G. Archibald, Director, Wellcome Tropical Research Laboratories, Khartoum.

Summary.—Blackarm disease of cotton caused by *B. malvacearum* has probably existed for some years in the Sudan as in other cotton-growing countries. The causal organism is endowed with feeble powers of resistance against sunlight, desiccation, and heat. The source of infection exists within the seed coat, as proved by cultural and other experiments. The causal organism has not been found in soil or water, and the epidemiology of the disease does not favour the hypothesis that the disease is insect borne. No hosts other than the cotton plant have been found. Unsuitable soil or climatic conditions, or imperfect agricultural methods, act as predisposing factors for the manifestation of the disease by lowering the resisting powers of the plant. As a prophylactic measure, seed treatment, by means of chemicals, has yielded disappointing results. In view of what is known of the infection within the seed, any such treatment to render seed sterile would appear ineffectual. The problem will be more effectively attacked by measures directed towards maintaining the plant's vitality by improved agricultural methods, including the use of manures and fertilizers. Seed from heavily infected crops should not be used for producing the next season's crop. Such seed might with advantage be stored, as storage appears to minimize seed infection.

514. Fusarium Moulds. Variability (Studies in the Genus Fusarium, III.). By W. Brown and A. S. Horne. (*Ann. Bot.*, 1926, **40**, 203-21. Abstr. from *Summ. of Curr. Lit.*, vi., **6**, 1926, A. 9.) A study of the variation under different cultural conditions of certain microscopic features of *Fusarium* strains, notably the degree of septation of the spores. There is a striking correlation between the intensity of staling shown and the degree of septation of the spores; the staled type of growth is associated with spores of low septation, the fresh with spores of high septation. Low septation is occasioned by high concentration of the nitrogenous and low concentration of the phosphate constituent of the

nutrient medium, the presence of growth-retarding substances in the nutrient, and increase of temperature. The carbon : nitrogen ratio of the medium largely determines the degree of septation of the spores, the nature of their contents, whether vacuolate, hyaline, or granular, and a number of minor characteristics. A table is given showing the correlation between spore length and degree of septation.

515. Fusarium Moulds. Saltation (Studies in the Genus Fusarium, IV.). By W. Brown. (*Ann. Bot.*, 1926, **40**, 223-43. Abstr. from *Summ. of Curr. Lit.*, vi., **6**, 1926, A. 10.) A study of saltation in *Fusarium* furnished no evidence of slow cumulative change during the culture of the strains investigated. Growth curves were determined for a number of strains under standard conditions, and repeated after an interval of a year and a half with results identical in all essential particulars. Inocula of spores in the case of some strains gives rise to colonies identical with those arising from mycelial inocula. Although small differences were noted, there is, in general, no essential difference between spore and mycelial inocula from the point of view of the colonies produced. Saltations which have taken place from time to time during the investigation are described. Saltation occurs more frequently on some media than on others. The new strains appear in isolated patches over the surface of the parent colony. The bearing of these results on the problem of preserving the vigour of strains is discussed, with suggestions for the maintenance of strains in their original form and the encouragement of saltations.

516. Two New Bacterioses of the Cotton Plant in Armenia. By P. Kalantarian. (*Centralbl. für Bakt.*, Ab. 2, lxv., 14-21, pp. 297-301, 1925. Abstr. from *Rev. App. Mycol.*, v., Pt. 3, March, 1926, pp. 161-2.) Describes two new bacterial diseases of cotton observed in Armenia. The first disease, which appeared in May in the districts of Etchmiadzin, Kamarlu, and Erivan, caused pronounced wilting, followed by withering and drooping of the foliage and eventual desiccation. In some cases a thickening of the stem at the root collar was observed. The roots were dry, with a brittle, blackish-brown cortex, which contained numerous bacteria, but no fungi. The organism is evidently closely related to *Bacterium herbicola aureum* and to *Phytobacter lycopersicum*, but since it cannot be identified with either, the new name *B. erivanse* is proposed.

The second disease was observed in August and September in the districts of Kamarlu and Sardarabad. The symptoms consisted of a pale yellowish intravenous discoloration of the foliage, followed by wilting, desiccation, and death in ten to fifteen days. Sections through the stalks showed a blackish-brown discoloration, extending the entire length of the vascular bundles. The organism could not be identified with any existing species, and has, therefore, been named *Bact. löhnisi*, n.sp.

517. Reduction of Loss in Cotton due to Diseases in the Bombay Presidency. By G. S. Kulkarni. (Paper read at the Indian Science Congress, 1926.) Discusses diseases (1) due to environmental factors, and (2) due to organisms.

518. Cotton Diseases in Porto Rico. By M. T Cook. (Abstr. in *Rev. App. Mycol.*, v., Pt. 4, 1926, p. 229.)

519. Sulphur as a Fungicide. I. Colloidal Sulphur. By H. C. Young, (Abstr. in *Phytopathology*, **13**, 1923, No. 1, p. 60. Also abstr. in *Exp. Sta. Rec.*, vol. **53**, 9, 1925, p. 847.)

520. The Dropping of Cotton Bolls. By R. A. Toro. (*Rev. Agr.*, Porto Rico, xvi., **1**, pp. 17-8, 1926. Abstr. from *Rev. App. Mycol.*, v., Pt. 5, May, 1926, p. 299.) The surprising fall of cotton bolls up to 20 per cent. observed recently

in the coastal districts of Porto Rico was attributed at first to the attacks of *Diplodia gossypina*, as several bolls examined were infected by this fungus. Others, however, showed no signs of disease, and the author is convinced that the cause must have been purely physiological. Dropping of the bolls, such as has been observed in Porto Rico, begins immediately after they form, and may continue with more or less intensity until the ripening period. Before dropping they lose their natural green coloration. Some of the smaller bolls die off, but will only drop if they are touched or the plant is shaken. The fall of the bolls is interpreted as a means by which the plant adjusts itself to changes of weather. An abundance of flowers may be produced, for the subsequent development of which the plant has insufficient nutriment at its disposal in the event of a period of heavy rains, with high temperature and vigorous transpiration, being succeeded by drought. A certain number of bolls are then shed in order that the remainder may mature normally. As an insufficiency of moisture in the soil during the flowering and fruiting period is considered to be the principal cause of the dropping, methods of control should be based on the conservation of soil moisture. Suggestions for securing this are given.

BREEDING, GENERAL BOTANY, ETC.

521. Gossypium. By Sir George Watt. (*Bull. of Misc. Information*, No. 5, 1926. *Roy. Botanic Gardens, Kew.*) The observations of the author may be described as constituting a *Classified Enumeration*, with brief diagnostic descriptions, of certain species of cultivated and wild cottons, specimens of which are preserved in the Herbaria of the Royal Botanic Gardens of Kew and Edinburgh.

The following new species and varieties are described, in addition to several already described in Sir George Watt's *Wild and Cultivated Cotton Plants of the World*:

G. Nanking Meyen, var. japanense, Watt
G. Nanking Meyen, var. canescens, Watt
G. Simpsonii Watt
G. soudanense Watt
G. africanum Watt
G. africanum Watt, var. bracteatum Watt
G. transvaalense Watt
G. abyssinicum Watt
G. Bakeri Watt

522. Egyptian Cotton, 894. (*Rev. Text.*, 1925, **23**, 1155; from *Le Phare Egyptien*. Abstr. from *Summ. of Curr. Lit.*, vi., **12**, 1926, E. 60.) A new cotton has been developed by Parachimonas in Egypt, which is said to possess all the good qualities of Sakellarides without its inconveniences. This cotton is known at present only by the number 894.

523. Maarad Cotton Cultivation in Egypt. (Abstr. from *Summ. of Curr. Lit.*, vi., 7, 1926, E. 41.) Maarad cotton is a variety grown from Arizona Pima seed in Egypt. The estimated crop of Maarad cotton for this year is, according to American advices, 700 to 800 bales of 500 lbs. each.

524. The Improvement of the Cotton Plant. By Trevor Trought. (Paper read at the Indian Science Congress, 1926.) A method of selection by pure line work is briefly described, which can be usefully supplemented by acclimatization work. The importance of the root system and the necessity for the production of local unit species is emphasized. The author states that artificial hybridization at the present stage of knowledge does not introduce any certainty of improvement along directed lines, but combined with selection probably increases the chance of obtaining desirable combinations of characters.

525. STUDIES IN GUJARAT COTTONS. PART III. THE WAGAD COTTON OF UPPER GUJARAT, KATHIAWAR, AND KUTCH. By M. L. Patel and D. P. Mankad. (*Mem. of Dept. Agr. in India*, vol. xiv., **2**, 1926.) Deals with the history of Wagad cotton, characteristics, conditions under which it is grown, the hereditary nature and the variation of certain characters, the correlation of certain characters, description of certain pure line strains, the ideal type of Wagad cotton for Upper Gujarat.

526. REPORT ON THE IMPROVEMENT OF ISHAN COTTON (G. VITIFOLIUM). By C. J. Lewin and T. G. Mason. (*Fourth Ann. Bull. of Dpt. of Agr., Nigeria*, August, 1925, pp. 109-14.) Describes experiments carried out with selected and unselected plants of *G. vitifolium* cotton brought from the Ishan district of the Benin Province, and grown at Ibadan, with a view to evolving a strain with longer and finer lint than the *G. peruvianum* variety usually grown in Southern Nigeria. The progeny of many of the plants were disappointing, but some very long stapled plants were secured, and there were no obstacles to the isolation of a number of long-stapled strains. Tables are included showing (1) frequency arrays for lint length of seed cotton from selected and unselected plants; (2) lint and seed characters of selections made from progeny of plants selected in the Ishan District; (3) frequency arrays of vegetative characters; (4) coefficients of correlation.

527. "HALF AND HALF" COTTON, U.S.A. (Abstr. from *Summ. of Curr. Lit.*, vi., **7**, 1926, E. 45.) The attention of the Secretary of Agriculture has been drawn to the notable falling-off in the strength and uniformity of cotton, especially in Texas, owing to the spread of such high yielding, but short-stapled, varieties as Half and Half. Extension of the community system is recommended. Letters from various Co-operative Societies show that these bodies are alive to the danger, and an extract from the *Cotton News*, S. Carolina, comments on the difficulties now experienced by the growers in disposing of Half and Half cotton.

528. COTTON PLANT. NATURAL HYBRIDIZATION. By L. Dekaprolevich. (*Bot. Abstr.*, 1926, **15**, 81. Abstr. from *Summ. of Curr. Lit.*, vi., **8**, 1926, A. 19.) In the event of mixed planting of cotton, the quantity of natural hybrids in the second generation reaches 7 per cent. By planting the two forms of cotton in alternate rows, it was found that natural hybridization amounted to 1-5 per cent. The insects which aid natural hybridization are mainly: *Anthrena dubitata, Halictus albipes, H. sexcinctus*, and *Apis melifica*.

529. A NOTE ON THE ABNORMAL BEHAVIOUR OF COTTON PLANTS WHEN SUBJECTED TO HANDLING. By M. A. Bailey and J. Templeton. (*Min. of Agr. Egypt, Tech. and Scientific Serv.*, Bull. No. 61. Obtainable Govt. Pubns. Off., Min. of Fin., Dawawin P.O., Cairo. Price P.T. 5.) Deals with the stunting observed in cotton plants that are much handled (as is the case on many experimental plots when flower counting is being carried out). The obvious explanation of the stunting of the plants seemed to be panning of the soil due to the trampling of the feet of the observers when making their daily round, but this appears not to be the case, and the authors put it down to the irritability of the plants themselves due to handling. They recommend that, except in special cases where the fluctuation of flowering from day to day is itself a matter of importance, routine flower counting should not be carried out every day, but that observations should be taken only every second, or even every third, day. In the earlier part of the season, when the flowers can be readily seen without touching the plants, observations might with advantage be carried out daily.

530. HERITABLE CHLOROPHYLL DEFICIENCIES IN SEEDLING COTTON. By G. N. Stroman and C. H. Mahoney. (*Texas Sta. Bull.* 333, 1925, pp. 3-22. Abstr. from *Exp. Sta. Rec.*, vol. **54**, 5, 1926, p. 428.) Two factor pairs, Y_1y_1 and Y_2y_2,

appeared to be involved in the production of the seedling character in cotton, yellow seed leaves instead of the usual green. The expression of "pattern," another chlorophyll deficient seedling which ranged from a seedling with distinct areas devoid of chlorophyll to one which has a small amount of chlorophyll throughout the leaf, is shown to be due to two (C_1C_2) and possibly three (C_3) different genetic factors. It is possible that two of these factors are linked. The amount of cross-fertilization in cotton in the field at the station in 1924 was estimated to be 2·46 per cent.

531. COTTON HAIRS. CLASSIFICATION. By W. M. Mebane and F. C. Vilbrandt. (*Amer. Dyestuffs Rep.*, 1926, **15**, 279-82. Abstr. in *Summ. of Curr. Lit.*, vi., **10**, 1926, A. 27.)

532. BIOMETRICAL STUDIES OF LINT AND SEED CHARACTERS IN COTTON. By G. N. Stroman. (*Texas Sta. Bull.* 332, 1925, pp. 3-20. Abstr. from *Exp. Sta. Rec.*, vol. **54**, 5, 1926, pp. 427-8.) Statistical studies of sixteen Texas varieties of cotton grown in variety trials at the station dealt with the type and variability and inter-relations of six important characters.

In mean yield of lint Bennett Lone Star led the varieties, and was most variable. Belton made the maximum mean yield of seed, and was the most variable variety. Mebane and Bennett Lone Star were close seconds in lint yield and seed yield respectively. The varieties ranged from Star with 42·84 per cent. of lint and Kasch with 42·67 per cent. down to Snowflake with 29·67 per cent. Snowflake with $1\frac{5}{16}$ inches was outstanding in mean length of lint, although it was more variable than most other varieties. Bennett Lone Star and Watson led in number of 5-lock bolls, and Snowflake in 4-lock bolls. The Star variety had the heaviest 5- and 4-lock bolls, and the 5-lock bolls outweighed the 4-lock bolls in practically all cases. Average ranges of 72·9 days to 77·3 days to first bloom, and of 111·8 days to 115·8 days to first open boll were observed in the sixteen varieties, showing that earliness might be developed through selection for this character.

All varieties showed positive correlations between yield of lint and seed yield number of 5-lock bolls, and number of 4-lock bolls. No consistent relations were shown in the case of different varieties between lint yield and lint percentage or lint length; between seed yield and lint percentage or lint length; lint percentage and lint length; nor between the percentage or length of lint with either 5-lock or 4-lock bolls.

533. THE ALKALINE REACTION OF THE DEW ON COTTON PLANTS. By C. M. Smith. (*Science*, 61, 1925, No. 1587, pp. 572-3. Abstr. from *Exp. Sta. Rec.*, vol. 54, **3**, 1926, p. 221.) The author reviews the criticisms of Mills, and of Power and Chestnut regarding the alkalinity of dew on cotton plants. Under a discussion of the question of the reaction of alkaline earth carbonates to phenolphthalein, attention is called to the presence in the dew of potassium equivalent to 252 parts of K_2O per million, a condition that would indicate the possibility of the presence of potassium carbonate in the dew.

On the cause of the alkalinity of the dew, the author claims that the question as to whether it is due chiefly to carbonates or to ammonia and trimethylamine remains to be determined.

534. SULPHATE CONTENT OF THE LEAF-TISSUE FLUIDS OF EGYPTIAN AND UPLAND COTTON. By J. A. Harris *et al.* (*J. Agr. Res.*, 31, 1925, **7**, pp. 653-61. Abstr. from *Exp. Sta. Rec.*, 54, **6**, 1926, p. 522.) In this continuation of previous research the authors show that the sulphate content of the Upland varieties, Meade and Lone Star, was higher than that of the Egyptian variety, Pima. It is contended that the Egyptian type takes up more chlorides and the Upland more sulphates.

535. EGYPTIAN COTTON LEAF-TISSUE FLUIDS. PROPERTIES. By J. A. Harris. (*J. Agr. Res.*, 1925, **31**, pp. 1027-33. Abstr. in *Summ. of Curr. Lit.*, vi., **8**, 1926, B45.) An investigation of the leaf-tissue fluids of five further varieties of Egyptian cotton was undertaken to ascertain whether all Egyptian varieties differ from Upland varieties, or whether in this respect Pima stands alone. The results show that while the Egyptian varieties differ among themselves, all the varieties considered have a higher osmotic concentration and specific electrical conductivity than the Upland with which they have been compared. The two types apparently do not differ in the ratio of the electrical conductivity to freezing-point depression. All the Egyptian forms have a higher chlorine and a lower sulphate content than the Upland types. Differences between individual Egyptian and individual Upland types are under investigation.

CO-OPERATION.

536. CO-OPERATIVE MOVEMENT IN INDIA. By H. Calvert. (*Agr. J. of India*, vol. xxi., **3**, 1926, p. 183.)

537. CO-OPERATIVE COTTON MARKETING. N. CAROLINA, U.S.A. (*Int. Cot. Bull.*, 1926, **4**, pp. 200-2.)

CHEMISTRY AND PHYSICS IN THEIR APPLICATION TO COTTON PROBLEMS.

538. MODERN IDEAS ABOUT COTTON. By A. J. Hall. (*Dyer and Calico Printer*, 1926, **55**, 66-67. Abstr. from *J. of Text. Inst.*, xvii., **3**, 1926, A66.) The first of a short series of articles on the physical and chemical properties of cotton. The growth within the boll, formation of striations and convolutions, cross-sections, and influence of wall thickness on dyeing properties of cotton fibres are described.

539. THE STUDY OF THE COTTON FIBRE. By A. J. Turner. (Paper read at the, Indian Science Congress, 1926.) *Summary.*—The paper is divided into three sections: (1) Structure and Composition; (2) Physical and Chemical Properties; and (3) Practical Aspects. In the first section a general description of the fibre is supplemented by an account of the recent work of Balls and Denham, and, in particular, of the former's view that the cell-wall of the cotton fibre consists of about twenty-five layers, each consisting of about forty fibrils running spirally from one end of the fibre to the other. The second section deals in some detail with recent work upon those properties of raw cotton which are considered to have an important practical aspect—viz., (1) length, (2) ribbon width, (3) area of cross-section, (4) wall-thickness, (5) weight, (6) strength, (7) tensile elasticity, (8) surface friction, (9) torsional elasticity, (10) plasticity, (11) lustre, (12) electrical conductivity, (13) porosity and permeability, (14) physical and chemical stability. It is pointed out that considerable difficulties arise in the measurement of these properties owing to the irregularity of the material. From irregularities in a single cotton fibre we proceed in an ever-widening circle of irregularity as we extend our consideration in turn to fibres from a single seed, a single boll, a single plant, a single variety in a given locality, different varieties in different localities. In the final section the general relationship of the various properties to practical problems of the cotton industry is briefly discussed. Emphasis is laid upon the difficulties besetting the interpretation of those properties in terms of practical utility and, as an example, their relation to the spinning value of a cotton is discussed in some detail.

540. THE CONVOLUTIONS OF THE COTTON HAIR AND THE "BEADING" PRODUCED BY TREATMENT WITH AMMONIACAL COPPER HYDROXIDE SOLUTIONS. By B. Vlock. (*Melliand's Textilberichte*, 1926, **7**, 361-4. Abstr. in *J. of Text. Inst.*, xvii., **7**, 1926, A171.)

541. Comparative Wearing Qualities of Pima and Ordinary Cotton used in Mail Bags. By F. R. McGowan *et al.* (*U.S. Dpt. Com. Bur. Standards Technol. Paper* 277, 1925, pp. 73-83. Abstr. from *Exp. Sta. Rec.*, vol. 53, **8**, 1925, p. 737.) Laboratory and service tests showed that catcher pouches made from Pima cotton duck will give better service than those made from ordinary cotton duck, and now being used by the U.S. Post Office Department. The Pima fabric withstood tearing strains incident to the service much better than the usual fabric. A suitable mill organization for the manufacture of yarn from Pima cotton was being developed.

542. Cotton Cellulose. Spontaneous Combustion. By F. Taradoire. (*Compt. rend.*, 1926, **182**, 61-3. Abstr. from *Summ. of Curr. Lit.*, vi., **6**, 1926, B34.) Cotton takes fire spontaneously in contact with air at a temperature of 210° to 220°; in contact with drying oils and dryers a temperature of 210° causes spontaneous combustion. It is found that the rapid oxidation of the drying oil is retarded to a greater or less degree if organic compounds such as phenols, quinol, aniline, and its derivatives are added to the treated cotton in quantities of 1 per cent. Powdered sulphur (2 per cent.) also retards oxidation, but only becomes active after the temperature has reached 100°.

543. Chemical Products of Cellulose. (*Indus. and Eng. Chem.*, **17**, 1925, No. 1, p. 33. Abstr. from *Exp. Sta. Rec.*, vol. 53, **8**, 1925, p. 718.) A condensed chart of the principal chemical products derived from cotton and from wool.

544. The Reflection of Light from Textile Materials and the Physical Causes of their Lustre. By G. A. R. Foster. (*Shirley Inst. Memoirs*, vol. v., January, 1926.)

545. Raw Cotton: Oil-Spraying in the U.S.A. By B. W. (*Cotton* [U.S.A.], 1926, **90**, 386. Abstr. from *J. of Text. Inst.*, xvii., **6**, 1926, A140.) Oil-spraying is not an entirely new practice. In one mill it has been in use for fifteen years, and the manager is understood to have brought the idea from Germany, where it seemed to be in common use. This mill uses waste and low-grade cotton, and with every load of waste introduced into the hopper a broom dipped in oil was banged on the edge of the hopper producing a shower of fine particles. The manager did not think much of the use of oil on good cotton, and does not use it on the little fresh cotton he runs. The author has discussed the practice with a number of men, and the consensus of opinion is that it is good on waste, or on dyed or bleached stock, but of questionable value on good cotton. Spinners running coarse, low, or medium grades favour oil spraying, but those running $1\frac{1}{16}$ inch or better, in Middling or higher grade, seemed to think oiling unnecessary, if not actually objectionable.

546. Cotton-Spinning Tests. (Abstr. from *Text. Recorder*, vol. xliii., No. 517, 1926, p. 50.) Cotton-spinning tests recently made by the United States Department of Agriculture indicate that the production of superior varieties of cotton is an advantage not only to the grower, but to the cotton trade, which the latter does not always appreciate. These tests have demonstrated that the pure strains of cotton are better from a manufacturing as well as from a production standpoint; they have a distinctly higher spinning value than ordinary gin-run cotton.

547. The Results of Spinning Tests on Standard Indian Cottons. (Ind. Centr. Cott. Comm. Techn. Lab., Bombay, 1926.) These tests were carried out at the Technological Laboratory of the Indian Central Cotton Committee, with the following objects in view: (1) To obtain as full information as possible about the Standard Indian Cottons, both as to their fibre character and their spinning capacities; (2) to prepare a series of standards by which to judge other cottons; (3) to examine the question as to what is the minimum weight of cotton on which a satisfactory spinning test can be carried out.

548. Feeding Value of Cotton Seed. (*Indus. Eng., Chem. News Edition*, April 20, 1926. Abstr. from *Trop. Agriculture*, iii., **6**, 1926, p. 123.) At the 71st meeting of the American Chemical Society at Tulsa, Oklahoma, in April of this year, a symposium on cotton and its products was held by the Division of Agricultural and Food Chemistry. Seventeen papers were presented, and of these five were read by their authors. A paper on gossypol and cotton-seed meal poisoning produced considerable discussion, and established the opinion that small quantities of gossypol are not poisonous, whereas larger doses are distinctly toxic, and that raw cotton seeds are more poisonous than seeds that have been heated or treated with solvents to remove oil. Another paper on the feeding value of cotton-seed meal showed that the stuff contains a high percentage of phosphorus, but a rather low percentage of calcium and sodium. When fed to animals it, therefore, needs balancing by mineral additions in order to render it really nutritive. The author of a paper on the proteins of cotton seed stated that before long these proteins will be extracted and used for human consumption.

549. Cotton Seed. Food Value. By D. Wesson. (*J. Oil and Fat Industries*, 1926, **3**, 121-4. Abstr. from *Summ. of Curr. Lit.*, vi., **10**, 1926, B. 54.) It is shown that cotton has important possibilities as a food crop. The refined oil is used for the manufacture of edible fats, but little attention has been given to the use of the meal. It is, however, possible to separate the meats of the cotton seed from the hulls, and to remove all oil and gossypol by solvents, when a product containing about 55 per cent. of protein is obtained. This protein makes a good meat substitute at a cost of 5 cents per lb. of protein as compared with 2 dollars per lb. for beef protein, and since there is on the market a material sold as beef extract which is made by peptonizing the proteins of wheat, it is suggested that there is nothing extravagant in the idea that a valuable meat substitute could be made from cotton seed protein.

550. Cotton Seed Analysis. By C. H. Cox. (*J. Oil and Fat Industries*, 1926, **3**, 125-7. Abstr. from *Summ. of Curr. Lit.*, vi., **10**, 1926, B. 54.) In the method described for the evaluation of a sample of seed in terms of pounds of cotton-seed oil and cake that can be produced, the treatment with concentrated hydrochloric acid before grinding and analysis is applied by soaking an ordinary porous flower-pot with the acid, filling loosely with a weighed quantity of seed and heating the whole in a ventilated air oven to 115° to 125° C. for 1 to 1½ hours. This method allows the sample to be ground to a homogeneous mixture.

551. Cotton-Seed Oil. Constituents. By G. S. Jamieson. (*J. Oil and Fat Ind.*, 1926, **3**, 153-5. Abstr. in *Summ. of Curr. Lit.*, vi., **13**, 1926, B. 78.)

HISTORICAL.

552. Cotton. (*Queensland Agr. Journ.*, xxv., 4, 1926, p. 378.) An historical review of the progress of cotton.

553. The Evolution of Cotton Marketing. By Dr. A. B. Cox. (Abstr. from *Int. Cot. Bull.*, iv., 4, **16**, 1926, pp. 522-35.) Gives under the following heads a concise history of the cotton industry from the earliest stage, and showing the evolution which has gradually taken place: Cotton Trade and Industry down to 1700 A.D.; Beginning of Modern Cotton Marketing (1700-1760); Period of Invention (1760-1800); Period of Development and Expansion (1800-1860); Period of Future Markets (1860-1914); Present Trends in Cotton Marketing.

MISCELLANEOUS.

554. COTTON-GROWING COUNTRIES, PRESENT AND POTENTIAL. (*Int. Inst. of Agr., Rome.* Pubd. by P. S. King and Son, Ltd., 2-4, Great Smith Street, Westminster, London. Price 12s. 6d.) This is a serious attempt to provide reliable statistics for the production of cotton in all parts of the world, and no less than seventy-nine countries are dealt with. Information has been obtained from the various Governments, from the Empire Cotton Growing Corporation and similar bodies, from Professor Todd's statistics, and elsewhere.

The book commences with a summary and notes. Areas are naturally extremely difficult of determination in many warm countries, but an honest effort has been made to get the figures to approximate as much as possible to the actual facts. It is of interest to note that for the years 1921-24, 68,923,000 acres was the average area under cotton, an increase of 4 per cent. on the years 1909-13. The rise has doubtless been due to the high prices of cotton, and now that these are falling, there will be less incentive to increase area. The whole question must be considered together with labour and its availability, provision and cost of transport, and many other questions.

As regards production, the average for 1921-24 is 9,439,000,000 lbs. lint, compared with 10,696,000,000 in 1909-13, or a decline of 12 per cent., in spite of increased area. But the greatly increased production of 1925 in the United States will change this result for that year at any rate.

A very useful table of dates of planting and picking in different countries is given on p. xxiv, and is followed by a table of sales of spot cotton in Liverpool, which shows the steadily increasing number of countries taking part. Incidentally, the rise of Peru may be noticed, and the falling-off in Brazilian supplies (in spite of increasing crops) because of greater home consumption.

Each country is then considered in more detail, and figures of area and production are given for a number of years. The first country mentioned is Bulgaria, which few people associate with cotton, with an area of over 5,585 acres and a production of 1,235,000 lbs. of lint in 1925, followed by Greece with four times as much. Rapid increases in production are shown in the case of most of the cotton-growing countries of the world.

The work ends with statistical tables of area, production, trade consumption, stocks, prices, etc. The figures given will be most useful to all concerned with the cotton industry and its extension.

555. COTTON FACTS. 50TH ANNIVERSARY EDITION OF 1925. (Shepperson Publishing Co., New York. Henry Young and Sons, Ltd., 12, South Castle Street, Liverpool.) This semi-centennial edition is replete with many new features, which include statistics on cotton and cloth exports, imports, manufactures, and production. Supplementary information on the cotton-seed section has also been added, to keep pace with the wider interest displayed in this commodity. Among the new features introduced in this edition may be mentioned the following: a review of production and cultivation in new regions, with particular attention devoted to Africa; a comprehensive table giving the world's production of Rayon; a table showing the monthly range of prices in Alexandria for "Egyptian Futures," and one comparing the exports of cotton yarn from the United States and the United Kingdom. Considerable data is also included on developments in China and Japan, and statistics are given showing the remarkable recovery in the textile industry in Soviet Russia since the culmination of the World War.

PERSONAL NOTES

We much regret to announce the death, at his residence in Ashton-under-Lyne, of Mr. Edward Judson. Mr. Judson was President of the Amalgamated Association of Operative Cotton Spinners; he was also a member of the Board of Trade Committee which recommended the formation of the Corporation, and he served upon the Administrative Council and Executive Committee of the Corporation from its inception.

We offer our congratulations to Sir William Himbury on receiving the honour of knighthood. Sir William Himbury is the Managing Director of the British Cotton Growing Association, and represents that body on the Council of the Corporation.

We also offer our congratulations to Mr. W. C. Bottomley, C.M.G., on receiving the honour of Companionship of the Order of the Bath. Mr. Bottomley represents the Colonial Office on the Council of the Corporation.

APPOINTMENTS.

Nyasaland.

Mr. E. Lawrence has been appointed as an Assistant Agriculturist in Nyasaland.

South Africa.

Mr. I. G. Hamilton has been appointed as Assistant to Mr. Parnell at Barberton, South Africa.

Mr. G. C. Ullyett has been appointed as an Entomologist serving under Mr. Milligan in South Africa, attached to the Department of Agriculture.

Southern Rhodesia.

Mr. A. G. McKinstry has been appointed as Assistant Plant Breeder serving under Mr. Cameron in Southern Rhodesia.

Mr. J. C. F. Hopkins, who was seconded by the Corporation in 1924 to the service of the Uganda Department of Agriculture, has been appointed Mycologist in the Department of Agriculture, Southern Rhodesia.

STUDENTSHIPS.

The following have been elected to Studentships under the Corporation for the year 1926-27. They will hold their studentships at the place named in the second column:

Seniors.

Name.	*Studentships tenable at*
D. W. H. Baker	Trinidad.
P. A. Bowmaker	Trinidad.
W. P. K. Findlay	Trinidad.
O. V. S. Heath	Trinidad.
M. Greenwood	Trinidad.
D. Macdonald	Trinidad.
U. J. Moffat	Nyasaland.
L. H. A. Stone	Trinidad.
T. Lloyd Williams	Trinidad.
J. L. Moerdyk	Trinidad.
V. F. O. Olivier	Trinidad.

JUNIORS.

Name.	Studentships tenable at
W. Allen	S.E. Agr. College, Wye
A. G. Bebbington	Cambridge.
H. R. Hosking	Cambridge.
H. Hutchinson	Cambridge.
A. H. Lewis	Rothamsted.
R. M. Maynard	S.E. Agr. College, Wye.

The two last-named Senior Students were appointed by Mr. Milligan in conjunction with the Ministry of Agriculture, South Africa, from amongst candidates drawn from the Union.

OFFICERS ON LEAVE.

When an officer of a colonial Department of Agriculture (or of the allied departments of Irrigation, Transport, etc.) comes "home" on leave, he usually brings with him much information that may be of considerable value to similar officers in other colonies, or to the officers of the Empire Cotton Growing Corporation, who have to collect, collate, and use all possible information relating to cotton. The Corporation would consequently much appreciate the courtesy if Directors of Agriculture and others would be so kind as to inform them, in advance if possible, of the names, probable addresses, and approximate dates of arrival in England of officers coming on leave. This would give the Corporation the opportunity of getting into touch with these officers themselves, and of giving the latter the opportunity of meeting with one another. A further courtesy would be conferred if the officers themselves, upon arrival, would call at, or inform, the offices of the Empire Cotton Growing Corporation, which are at the corner of Millbank and Wood Street (entrance by the first door in Wood Street) immediately opposite to the offices of the Crown Agents for the Colonies.

At the date of writing the following officers are on leave in England from cotton-growing countries:

Barbados	Prof. J. P. d'Albuquerque.
Gold Coast	Mr. M. Vardy.
,,	Mr. W. H. Beckett.
,,	Mr. W. K. A. J. Chambers-Hunter.
,,	Mr. F. N. Howes.
India	Mr. G. R. Hilson.
,,	Mr. A. J. Turner.
,,	Mr. W. Youngman.
Iraq	Mr. J. F. Webster.
Kenya Colony	Mr. F. B. L. Butler.
,, ,,	Mr. E. Harrison.
,, ,,	Mr. R. J. Lathbury.
Nigeria	Mr. B. Browne.
,,	Mr. S. M. Gilbert.
Nyasaland	Mr. F. Barker.
Tanganyika	Mr. A. E. Haarer.
,,	Mr. O. E. Whitehead.
Uganda	Mr. A. S. Widgery.

Mr. B. C. Burt, Secretary of the Indian Central Cotton Committee, is on leave in England.

Mr. T. McEwen, a member of the Corporation's staff abroad, is also on leave in this country.

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